MANAGING PRODUCT INNOVATION:

ACTUAL PRACTICES OF NEW ZEALAND INDUSTRY REGARDING USE OF KNOWLEDGE MANAGEMENT IN ENGINEERING NEW PRODUCT DEVELOPMENT

A thesis submitted in partial fulfilment of the requirements for the Degree

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GLOSSARY

ANOVA:	Analysis of variance: Statistical method of determining whether two sets of data are different based on comparing their means and standard deviations.
Association rules:	Statistical method for finding association and patterns in data, including qualitative variables.
Codification:	Refers to storing codified knowledge (e.g. presentations) in a database, typically with an intranet or web front end.
Codify:	Transferring knowledge into documents.
Database:	Collection of data with an intranet or web front end; network drive; software database; wiki or combinations thereof.
Innovation:	In this context innovation refers primarily to the development of new (novel) products in an engineering environment though not excluding the broader interpretation of improvement in production process or service.
Intellectual capital:	Refers primarily to collective knowledge of individuals in an organization and the value thereof (e.g. competitive advantage).
Knowledge management:	Includes all the processes used to store knowledge and to make it accessible within an organization.
New product development:	In this context NPD refers primarily refers to the entire process of engineering novel products from the beginning to the end of the project.
Organization:	Any type of corporate body that exists to serve a purpose, including business company, institution, governmental department.
Personalization:	Includes all personal knowledge sharing processes within an organization (e.g. meetings, presentations).
Statistical significance:	ANOVA was used to examine the statistical significance of the survey results. If the p-value was 0.5 or <0.5, then the result was considered statistically significant.

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ABSTRACT

Knowledge management (KM) is an essential, if sometimes overlooked part of new product development (NPD). It describes the way information and new knowledge is being shared in a commercial organization, hence, how it is stored and made accessible within an organization.

KM is applied to many organizational settings, but the application is sparse. KM has the potential to assist NPD, as previously acquired knowledge can be used more efficiently and redundant work can be avoided. However, there is no successful model or guideline for KM in an NPD environment.

This project specifically examined the NPD situation, and the research questions included: What do engineering companies in New Zealand do, if anything, to store acquired knowledge? What would encourage engineers to share their knowledge in NPD projects?

These research questions were answered by two methods: a survey and then follow-up face-to-face interviews were conducted. Statistical analysis identified various factors as important. Further, differences between New Zealand and German companies were examined. The survey and interview results showed that knowledge was found definitely important for innovation and NPD. However, Germans tended to rate the overall importance of knowledge higher than New Zealanders. It was found that all NPD companies used codification and personalization KM strategies to store knowledge and to make it accessible. However, a tendency towards a stronger emphasis on personalization was found. Particular knowledge sharing encouragements were identified that could result in a higher willingness of engineers to share their knowledge; supporting a communicative work-climate, setting up regular meetings for knowledge exchange and active encouragement to share knowledge. Apart from encouragements, survey and interview results also pointed out the importance of a clearly set direction for KM from management. Companies that were associated with successful KM did not only apply one particular KM process, but a combination of many. Particular KM practices and knowledge sharing encouragements were associated with KM success; the creation of a tidy, well structured database, regular meetings for knowledge sharing, supporting a communicative work-climate and active encouragement of staff to share their knowledge. Furthermore, the influence of personal relationships, trust and power differences on personal knowledge sharing processes were identified. Poor personal relationships and a low perceived level of trust can decrease the willingness of engineers to share knowledge. Engineers found that the most difficult situation in which to seek knowledge was from superiors, while the easiest was from peers. Thus organizational design and hierarchy structures can have an influence on KM.

These results were used to construct an integrative model that describes the factors, and their interaction, for successful KM in NPD.

Based on the interview and survey results, the main implications for practitioners are that an overall awareness of KM and the benefits thereof for the company itself and the employees are important for successful KM. Executives should consider setting direction, providing the required tools for KM, educating staff regarding KM, and actively encouraging knowledge sharing processes. Further, executives should be aware of the influence of organizational design on personal knowledge sharing mechanisms. NPD project managers should consider educating their project team regarding KM. Especially for the successful application of personal knowledge sharing processes it is important that project managers are aware of personal relationships and potential issues among their team members. In order to achieve a high willingness to share knowledge within the project team, project managers should consider supporting a communicative work-climate, setting up regular meetings for knowledge exchange and actively encouraging their project team members to share their knowledge. These methods were associated not only with a high willingness of employees to share knowledge, but also with KM success in general. Engineers should consider contributing to the KM process by applying the company's KM strategy and by having a high willingness to share own knowledge and ask questions to acquire knowledge. Furthermore engineers need to be aware of personal relationships with their colleagues and try to maintain a good work-climate, as this affects personal knowledge sharing processes within the NPD project team.

New product development requires knowledge, and in an organizational context that knowledge needs to be managed if there is to be an enduring future for the firm. This work has surveyed industry perspectives and identified factors that contribute to successful knowledge management, creating an integrated model that is applicable to new product development.

1 INTRODUCTION TO THE PROBLEM

1.1 IMPORTANCE OF KNOWLEDGE MANAGEMENT FOR NEW PRODUCT DEVELOPMENT

New product development (NPD) can be described as 'the process by which a new product idea is conceived, investigated, taken through the design process, manufactured, marketed and serviced' (Komsan, 2009). It 'includes all activities from development of the idea or concept for the product, the development of the product and its processes, and the launch of the product into production and into the market place' (DRM, 2007). It is considered as 'among the essential processes for success, survival, and renewal of organizations, particularly for firms in either fast-paced or competitive markets' (Brown & Eisenhardt, 1995).

However NPD projects differ from normal projects in several ways. First, a high degree of innovation and research is usually required. Furthermore, 'new product development is one of the most knowledge intensive processes in business and is itself constantly creating new knowledge' (Li, Ye, & Zou, 2007). Therefore knowledge and expertise are important in innovative engineering companies, hence knowledge management (KM). In the literature KM is considered 'an important and effective method that helps enterprises to improve NPD performance' (Li, et al., 2007). Further, it has been found that new product success was positively related to team learning (Lynn, Abel, Valentine, & Wright, 1999).

NPD companies tend not to make their profit based on one single innovation; they are dependent on continuous innovation, the creation of ideas and new high quality products. The model of Crisp represents this well, see *Figure i*, by showing conceptually that there is an ongoing process of innovation. There are many other models of the design process (Pahl & Beitz, 1988) (BS7000, 1989; Pons & Raine, 2005), and they all include the concept that innovation is important, and that the cycle continues.

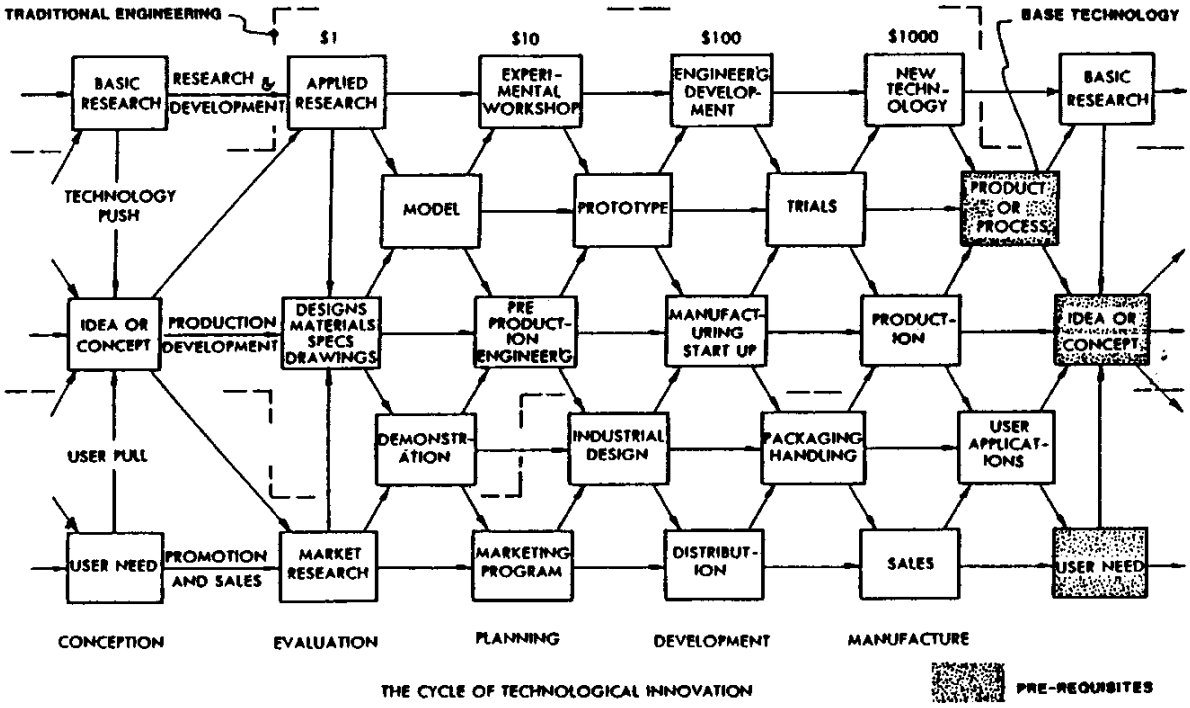

Figure i: Crisp's model of the design process as a self-repeating network (Crisp, 1986)

However, what is missing from the NPD perspective is an awareness of the need to provide a *mechanism for the reuse of knowledge*. Thus, while the need for continuous cycles of product improvement is well-understood, there has not been much attention on how the underlying knowledge will be retained for that next product. Apparently most design models implicitly rely on the continuity of employment of the engineering designers to provide that persistent thread of re-usable knowledge. That might have been a reliable premise in the days when jobs were for life, but with modern tendency to arrange work as short-term projects, and with current rates of organisational turnover and outsourcing of work packages, it can no longer be assumed that the same staff will be available for the next project. What then happens to the continuity of the knowledge? Consequently it is essential for innovative engineering companies to manage their knowledge properly in order to be successful with NPD. Furthermore, the way knowledge is shared and transferred within the organisation contributes to creating an innovative climate.

Thus there is a need to better understand how knowledge may be managed within the process of new product development. The situation under examination is therefore KM processes specifically for NPD, rather than knowledge management generally. Nonetheless, the scope is not limited to only the obvious engineering design activities, but instead includes the wider organisational context. This is consistent with the design perspective that understands design to be embedded within a set of organisational activities (Hales, 1994), see *Figure ii*.

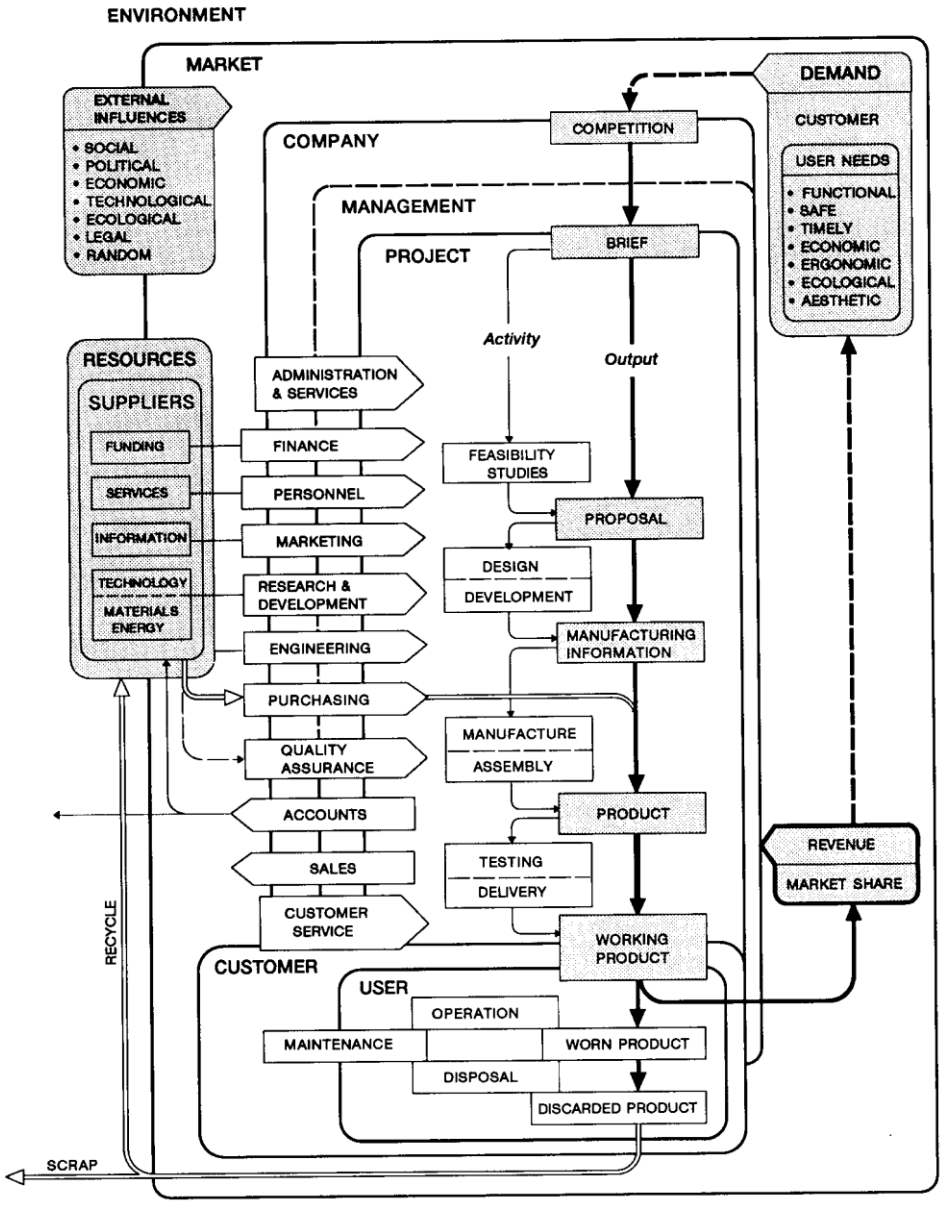

Figure ii: Hales' model shows design embedded within an organisational setting (Hales, 1994).

The present work expands the organisational context still wider, by specifically including the organisational behaviour effects of management strategies and choice of tools, personal relationships between workers, and organisational culture. Thus the purpose of this work is to explore the use of knowledge management in engineering new product development. The specific context is the New Zealand industry. The focus is on the tools used to manage knowledge, as well as the organisational methods and human behaviours involved.

1.2 CONTEXT: ISSUES AT THE INTERSECTION OF PROJECT MANAGEMENT AND NPD

This section summarizes the existing methodologies for managing innovation in NPD. It provides the larger picture background and thus the context in which the present project is framed.

1.2.1 PROJECT MANAGEMENT FOR NPD

A guide to the project management body of knowledge (PMBOK® Guide) (PMI, 2004) provides information for project managers and is a common tool for practitioners. It describes areas they might have to consider. In the PMBOK® Guide, nine areas of knowledge within project management are identified; project integration management, scope management, time management, cost management, quality management, human resource management, communications management, risk management and procurement management.

While every project implies a certain degree of risk, this degree is even higher with NPD. The scope and the work-breakdown-structure can be uncertain and dynamic, and this is hard to manage with conventional tools of project management. It was found that 'innovation in product development is a kind of highly risky exploration' (Buyukozkan, 2008). Also NPD is considered 'a complex and difficult business decision-making process' (Choi & Ahn, 2010).

There might also be a lack of experience regarding new technologies that might be used for example, which could make the NPD process even more difficult to handle. As a result NPD projects might be very hard to manage. Also the overall goal could be hard to define. But if senior managers do not set clear and relatively stable goals (Barczak & Wilemon, 2003), they could risk poor motivation of their staff. It is possible that even though NPD projects imply rather different attributes, they are still often being handled as any other project.

Project management tools are often being used for NPD projects and considered 'generally useful for managing NPD projects' (Pons, 2008). It is assumed that 'in some areas, project management incompletely meets the needs for NPD' (Pons, 2008), and thus, the results are not fully satisfactory. Why?

There are two general explanations. First, the methods of project management are not always applied properly (PMI, 2009). This could be for various reasons, for example a lack of knowledge or an attempt by the staff to simply avoid accountability.

Second, it has to be considered that the conventional project management principles might not be suitable for NPD projects. Their high degree of uncertainty can be too complex to handle with common methods. The causality between factors and project success has to be better understood. Also project management methods have to be better adapted to serve the NPD process (Pons, 2008).

Project management might not always be effective for NPD, and there appear to be several areas where the method is imperfect. These were identified as primarily in the area of managing resources under considerable uncertainty of outcomes. In particular knowledge management, strategic human resource management, lean management and decision-making were identified as significant gaps. The issues with these four areas are described in the following sections. However, there are still more gaps in the intersection of the PMBOK® Guide and NPD (e.g. different leadership styles, social and behavioural aspects and their impact on projects).

1.2.2 KNOWLEDGE MANAGEMENT

In some ways knowledge management is just communication. It describes the way information and new knowledge is being shared inside and outside the group. Teams with better communication have been associated with better performance (Hayashi, 2004). Also it is assumed that such communication is beneficial for organizations and therefore should be supported. Knowledge gathered during projects can be very useful for future projects. Hence, sharing and formalizing this knowledge is considered potentially valuable (Marsh & Stock, 2003; Olsen, 2002).

Much of the focus is on knowledge management generally, the business context, and the use of information and computer technology (ICT) to record and reuse information, rather than NPD specifically. Typically the value of KM is framed in terms of the strategic value to the organisation as a whole. Thus the knowledge an organization processes is considered an important component in order to reach its strategic objectives (Barcelo-Valenzuela, Sanchez-Schmitz, Perez-Soltero, Rubio, & Palma, 2008). This is consistent with the empirical evidence that companies overwhelmingly perceive knowledge management to be important for them (Call, 2006).

Persistent questions, which are relevant to all areas of KM and still not fully understood, are:

- How can people be encouraged to share their knowledge?
- Which climates could be beneficial; hence, which organisational culture is useful?
- How can prior knowledge be accessed during projects?

- What are the applications for practitioners in specific situations? (There are so many situational variables, i.e. contingency factors, that obtaining robust recommendations for a specific situation is still difficult to achieve.)

It would be worthwhile solving these questions, for NPD in particular, because doing so would result in benefits for the management of these projects.

1.2.3 STRATEGIC HUMAN RESOURCE METHOD (SHRM)

Human resource practices within organizations are often designed to enforce a certain behaviour which is believed to be beneficial for the company's success (Azhdar, Farhad, & John, 2004; Orlitzky & Frenkel, 2005; Paul & Anantharaman, 2003; Pons, 2008; Sheehan, 2005). This is called strategic human resource management (SHRM). Like NPD, SHRM has an interest in innovation. There are still questions to be answered though, with respect to NPD in particular.

- How does SHRM affect people working on projects?
- What is the best way to manage and lead NPD teams?
- Which leadership styles result in the best outcomes?
- What is the opinion of the employees?
- What are the applications for practitioners?

Further research in this area could help to avoid mistakes in human resource management that could have a negative impact on NPD projects. Certain encouragements that are supposed to motivate staff can actually result in a negative outcome, e.g., workgroup competition suppresses knowledge sharing (Burgess, 2005). While there are approaches to analyze the impact of SHRM on human resource management (Way & Johnson, 2005), its influence on NPD projects is still not entirely clear.

Also the style of leadership has been identified as important for success (Clift & Vandenbosch, 1999; Lewis, Welsh, Gordon, & Green, 2002; Swink, 2005). Hence, it is worthwhile to get a better understanding of different kinds of leaderships in NPD and their influence on the outcome of a project.

1.2.4 LEAN PROJECT MANAGEMENT

Lean project management is an attempt to transfer some of the methods from lean manufacturing to project management. This includes concepts like just-in-time or the minimization of inefficiency (Freire & Alarcon, 2002) and control of workflow (Ballard et al., 2005; Chua, Shen, & Bok, 2003).

Transferring knowledge from lean manufacturing to project management could have some benefits. All embodiments of lean management target steady improvement, minimization of waste and inefficiency, worker empowerment, control of workflow, partnerships and concurrent management (Pons, 2008). Whether or not the lean approach could add value to project management is not entirely clear (Haque, 2003). Lean project management is currently still a developing concept and not yet entirely defined (Pons, 2008). Thus more fundamental research is required.

Issues for NPD are:

- What exactly is lean management in the NPD context?
- Which concepts does it imply?
- Is it suitable for NPD projects with high uncertainties?

1.2.5 DECISION-MAKING

Because of the high uncertainties during NPD projects and therefore the high risk, there are approaches to better manage these uncertainties. One approach is called stage-gate (Cooper, 1990). During the project certain milestones have to be reached. Then it has to be decided whether or not the project should be continued. After each stage a gate will be reached when this decision has to be made and the previous stage can be reviewed.

The problem is that the complexity is high. The stages and milestones are not always clear beforehand. Furthermore stage-gate tends to be risk-averse (Buggie, 2002) and thus maybe not unconditionally suitable for NPD.

The relevant questions for NPD in this context are:

- Which problems can be identified?
    - Sunk cost bias.
    - Time spent.
- How does stage-gate affect motivation?
- How is stage-gate and project closure integrated in project management?
- How efficient is stage-gate?
- What are the decision criteria?
- Is stage-gate suitable for NPD projects?

Serving as a blueprint for managing the new-product process, stage-gate systems have been shown to reduce new-product development cycle times while simultaneously improving their "hit rates" (Cooper, 1990).

Benchmark studies have also shown that companies using the stage-gate process achieve faster times to market, earlier detection of failures, higher success rates, more projects on time and cost targets, better cross-functional communication, and greater customer satisfaction (Cooper & Edgett, 1996).

A reason for that is that through applying stage-gate properly, companies can close projects that are not worth continuing. They save time and resources which they can assign to other more important and promising projects. By focussing on the relevant projects only, good outcomes can be produced faster. An explanation for the higher "hit-rate" is that the stage-gate process can focus the whole project team on the relevant criteria. The objective of the product can be made clear at the very beginning and the progress can be reviewed, assuring that the project is going in the right direction. By reviewing the project at every gate, failures can be detected earlier as well.

So if stage-gate could be used for NPD, there would be some promising advantages. Therefore it is worthwhile to solve the open questions as to NPD and stage-gate.

1.3 SUMMARY OF MAJOR GAPS

Four areas at the intersection of project management and NPD that require further research were identified. These are knowledge management, lean management, SHRM and decision-making (stage-gate). It is quite possible that other gaps exist beyond the four major ones identified in this paper.

The present work specifically addresses only the first area, knowledge management in particular for New Zealand NPD industry. It peripherally addresses some of the other questions where relevant.

1.4 PURPOSE OF THIS PROJECT

New product development (NPD) is a well-known part of the engineering design methodologies, and has a large extant literature and several research frontiers. Likewise knowledge management (KM) is an established organisational process, and similarly has a large literature. It is self-evident that NPD involves knowledge, and that often that knowledge must be reused in the subsequent engineering development of improved products and new families of products. Similarly, KM requires that there be some knowledge of worth that needs to be managed, i.e. the knowledge has a context that is relevant to the organisational purpose. In this study, those would be organisations involved with engineering new product development.

However the two disciplines, NPD and KM, are somewhat disconnected from each other. For example, KM is not yet a commonplace idea in the NPD community, at least as represented by current textbooks and research directions. Similarly, the KM literature is primarily in the business discipline, and it is uncommon to find engineering design specifically mentioned as the subject: instead the knowledge is typically treated as simply decontextualised knowledge.

This work therefore sits at the nexus of the engineering and business perspectives, and seeks to develop the conduit so that the ideas and positive practices of each can flow across and influence each other. The specific area of focus is engineering new product development in the New Zealand context.

Thus the purpose of this work was to research the KM practices of New Zealand's (NZ) engineering industry. Questions that we are interested in include:

- Is knowledge considered important for innovation and NPD?
- What do companies in New Zealand do, if anything, to store acquired knowledge? And if they don't do anything, why is that?

- What would encourage engineers to share their knowledge in NPD projects?
- What are the implications for practitioners?
- Are there any particular practices that result in successful KM? And what are the potential problems they might want to keep an eye on?

This is worth doing as it is well-established that knowledge a company possesses is considered one of the most important factors for organizational success (Barcelo-Valenzuela, et al., 2008). If a company has superior knowledge in a particular area, products can be launched earlier, with superior design (Wallace, 2005) and with higher quality compared to competitors. Knowledge is considered as the answer to the new competitive challenges faced by firms today (Lloria, 2008), and there can be little doubt that NZ has some significant successes but also major economic challenges in its high-technology manufacturing sector: a sector in which design innovation is crucial.

Furthermore, there has been only limited KM empirical research in the NZ context, and even less targeting the NPD process itself. One local study was that of McCullough et al who examined current practices regarding KM in New Zealand and found that 'the lack of a clear connection between KM and innovation (new products and services) is an area requiring further analysis' (McCullough, Oliver, Symonds, & Brown, 2004).

The rest of this thesis reviews the specific literature in this area, and presents the results from a survey, and grounds the findings in a set of case-study reports to answer the research questions.

2 LITERATURE REVIEW: KNOWLEDGE MANAGEMENT

There are large literatures for each of KM and NPD, and this section reviews the literature at the intersection of these two fields.

2.1 THE BASIC PRINCIPLE OF KM

The basic concept of KM is to capture and to reuse the knowledge of individuals, thereby equipping the organization for innovation. The knowledge held by the individual is central, being the precursor to organizational knowledge (Nonaka, 1994). Thus the main objective is to extract that knowledge and to store it in order to be able to access it in the future. The means to extract knowledge can be, for example, interviews, observations or simulations.

2.2 INTRODUCTION TO KM

Knowledge is an essential input to the innovation process which underpins new product development. However, 'just like knowledge itself, KM is difficult to define' (Earl, 2001). Some definitions of KM follow:

- 'Knowledge management deals with the management of knowledge related activities such as creating, organizing, sharing and using knowledge in order to create value for an organization. It is promoted as an essential cornerstone for companies to develop sustainable competitive advantage and to remain at the forefront of excellence in a level playing field market.' (Wong & Aspinwall, 2004)
- 'Knowledge management seeks to facilitate knowledge flows and sharing to enhance the productivity of individuals and hence the enterprise.' (Guns & Välikangas, 1997)

Further, 'new product development is one of the most knowledge intensive processes in business and is itself constantly creating new knowledge' (Li, et al., 2007).

The main processes within KM are recording (or capturing) knowledge, measuring if not quantifying it, managing it, making it accessible, reapplying it to new situations, and creating new knowledge (Lloria, 2008).

KM is a recognised area of business practice, and also an ongoing area of research. Various other disciplines, particularly economics, engineering, and psychology, have made contributions to the growing body of knowledge. However there is no integrative framework (Lloria, 2008), so the field tends to be characterised by a variety of models.

Regarding the application of KM to the specific situation under examination, namely New Zealand industry and the economic and cultural context in which it is embedded, there is limited empirical research. One such study is that of McCullough et al who surveyed private and public sector organisations (McCullough, et al., 2004) to examine current practices. They presented participants with a set of definitions of knowledge management and asked them to select their preferred interpretation. The majority of respondents (82.2%) chose a business-focussed definition: 'the collection of processes that govern the creation, dissemination, and utilisation of knowledge to fulfil organisational objectives'. The competing definitions were the technology of information-capture, the ability to manage knowledge, and intellectual assets.

The full set of definitions was:

- a technological concept: 'the use of information technology to capture data and information in order to manage knowledge'
- a business-focussed approach: 'the collection of processes that govern the creation, dissemination, and utilisation of knowledge to fulfil organisational objectives'
- a situation where no visible processes are used but it is 'simply the ability to manage knowledge'
- KM is about intellectual assets: 'taking the form of documents and information bases'.

This result suggests that NZ organisations perceive KM in a relatively mature manner, and aligned to organisational purpose. However, it could also be said that the business-focussed definition was richer, compared to the simplistic propositions of value proposed by the other definitions, and that any respondent in a management role would have a natural tendency to perceive KM as business process. Thus, to the extent that the respondents were managers, as opposed to other professional or labour roles, the results are unsurprising. All the same, it does show that at least managers had clear expectations about the end-goal of KM (the fulfilment of organisational purpose) and the means to achieve it (collection, dissemination, and reuse of knowledge). By comparison, much of the other literature focuses on the information technology processes for capture of knowledge, and one sometimes gets the feeling that the re-utilisation is an afterthought.

2.3 CLASSIFICATION OF KNOWLEDGE

Knowledge is sometimes describes as ‘a more elusive concept’, while data and information are easier to define (Blair, 2002). The types of knowledge that concern KM have been categorized into:

- Intellectual capital (IC) (patents, technology licenses) (Brooking, Board, & Jones, 1998)
- Structural capital (production processes including financial and manufacturing)
- Human capital (people professional skills) (Goh, 2005)

Thus Knowledge is principally found in people and is developed through learning (Lloria, 2008). Personal knowledge (of an employee) is extremely valuable for an organization, but not all of this is accessible as there is a distinction between explicit and tacit (implicit) knowledge (Nonaka, 1994). Explicit knowledge is that which can be readily expressed, while tacit knowledge is held to be internal and therefore is more difficult to capture. However, it is considered to be ‘what the practicing expert knows’ (Blair, 2002), and therefore could be very important for the company in the fulfilment of its objectives.

Possibly part of the problem is an issue with the term ‘tacit knowledge’: it may be overloaded with too many different meanings. Pons proposes a distinction between factual knowledge (e.g. data), procedural knowledge (e.g. sequence of events, rules) and intuitive knowledge (e.g. design and complex decision-making) (Pons, personal communication, 2010).

The design literature distinguishes between different phases within the design-process. Typical phases are conceptual, embodiment, and detailed design, though other breakdowns are also possible. It has also been possible to record the amount of time designers spend on these phases over the project life (Whybrew, et al., 2002), see *Figure iii*.

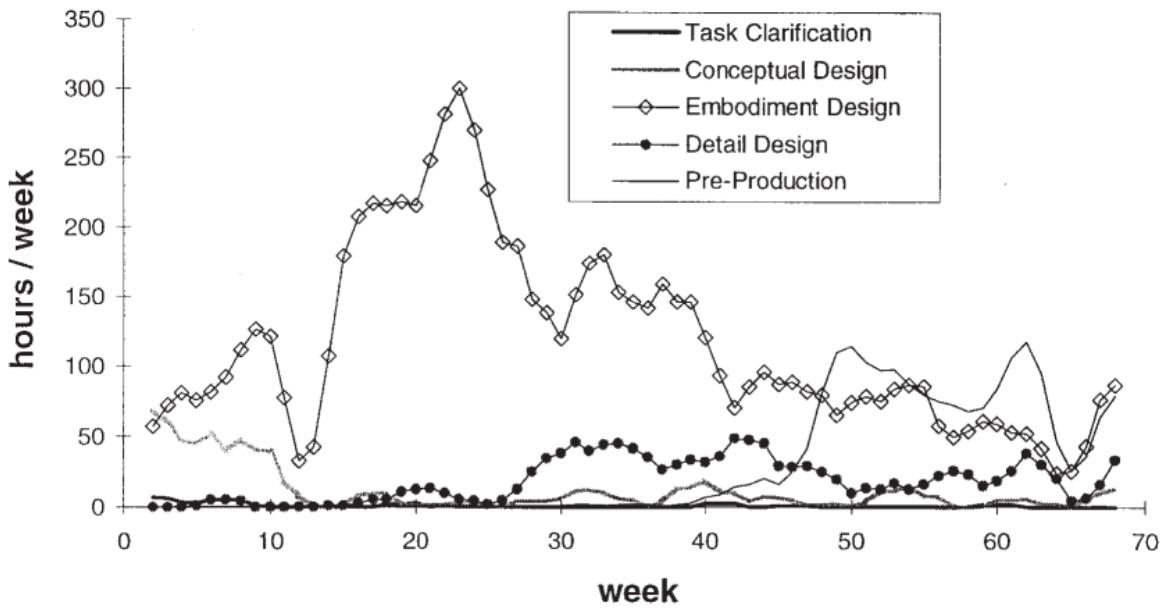

Figure iii: Profile of activity in the various design phases for a case study (Whybrew, et al., 2002)

Another perspective on the design phases is provided by Pons and Raine, who identified the activities involved with each phase, see *Figure iv* (Pons & Raine, 2005). There are two features of this model that are particularly relevant to the present work. The first is that Pons and Raine identified the mechanisms that are used to achieve the various activities (see the boxes with dashed outlines in the figure). Thus we can anticipate that different types of knowledge are used at different phases of the design process. The implication is that different types of knowledge are involved in NPD, and the mechanisms for managing that knowledge need to be able to cope with that diversity. Thus knowledge in the NPD context is not a simple mono-type variable, but includes knowledge of methodologies as well as specific product data. (This becomes important later in that the survey questions specifically seek to identify what forms of knowledge practitioners are using.) The second particularly interesting feature of the model is that those authors specifically identified one particular form of knowledge management, namely the need to 'record and retrieve the design intent'. Knowing what the original designers had in mind is therefore identified as important knowledge for later design-improvements or the development of derivative products. This is consistent with the observation, made earlier, of the strategic importance of knowledge management within the processes of innovation and organisational competitiveness.

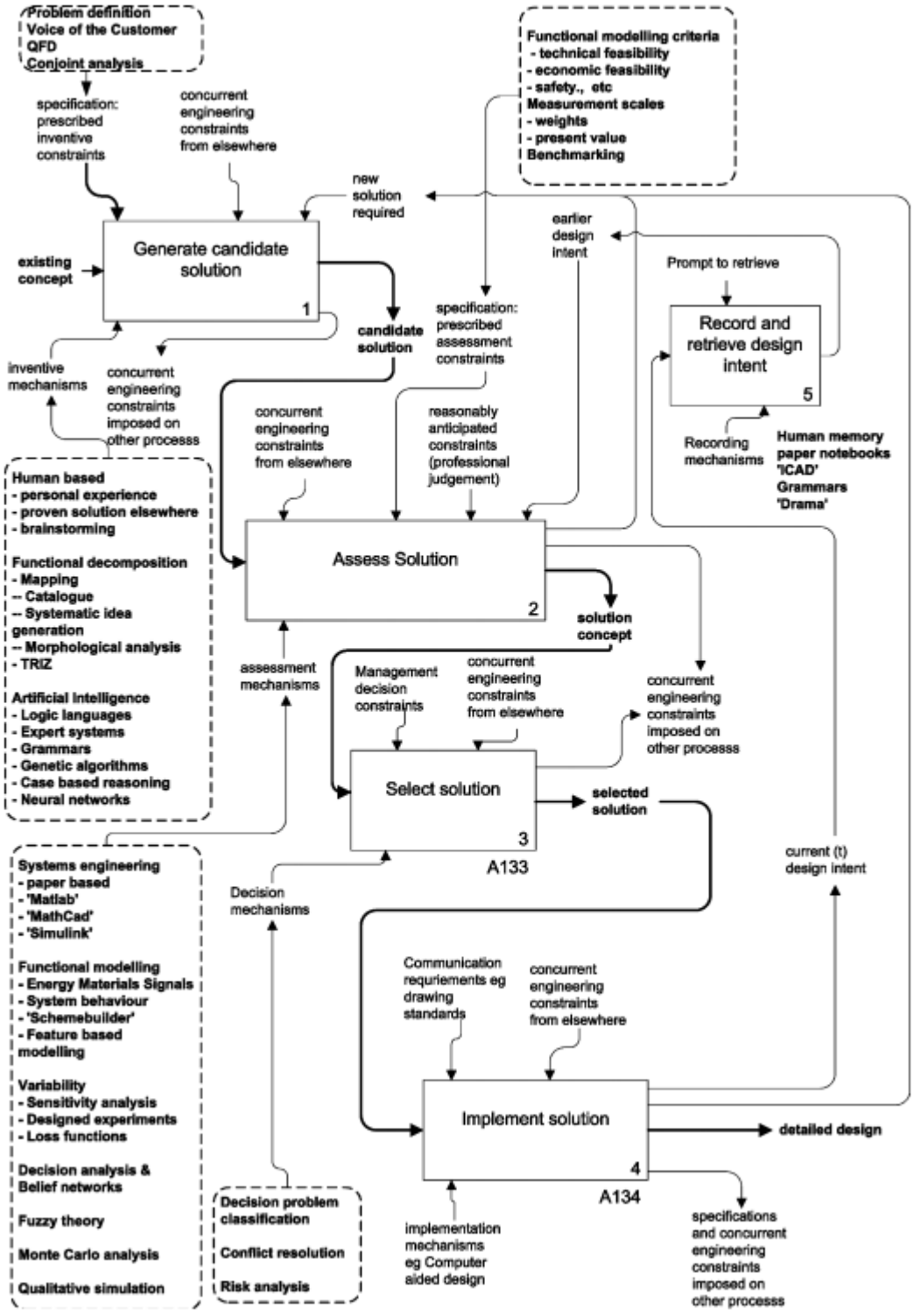

Figure iv: Pons and Raine's model shows different phases in the design, and the mechanisms used to make the decisions (Pons & Raine, 2005) . Implicit in those mechanisms are different types of knowledge. These authors also specifically identified one particular form of knowledge management, namely the need to 'record and retrieve the design intent'.

2.4 WHAT IS THE VALUE OF KNOWLEDGE?

The potential benefits of KM for an organization are commonly held to include:

- Relevant knowledge can be found and accessed when it is needed.
- New staff can be trained faster, hence add value to the organisation faster.
- An innovative work climate can be created.
- Redundant work can be minimized (saving time and money).
- The vulnerability of a company regarding staff leaving can be reduced.

Nonetheless, it is often not all that easy to distinguish the actual from the potential benefits. Which is to say that, while the benefits look attractive, the process whereby an organisation obtains them is more uncertain. Thus, a better understanding of how KM practices do and don't work in practice, could be helpful for NZ NPD firms in more effectively implementing KM processes that work.

There is no doubt that one of the most important components that help an organization achieve its objectives is the knowledge it possesses (Barcelo-Valenzuela, et al., 2008). The competition in today's market is intense. Knowledge is considered as the answer to the new competitive challenges faced by firms today (Lloria, 2008). If a company has superior knowledge in a particular area, products can be launched earlier, with superior design (Wallace, 2005) and with higher quality compared to competitors. This results in an advantage in the market. Moreover the product many companies sell is in fact their knowledge and the expertise (e.g. consultancy companies) thus knowledge should be seen as one of the core competencies of the organisation (Prahalad & Hamel, 2006).

Knowledge is considered as an essential input to the innovation process, and it also is the basis of most new product developments. Especially when much research is required, comprehensive knowledge is a critical advantage. Furthermore the production of complex products can be realized and through the application of knowledge and know-how the resulting costs can be kept on a lower level compared to competitors.

Nevertheless most companies in major industrial nations cannot keep up with foreign competitors as to the price of a product. Thus other competitive advantages have to be found. Literature suggested that the rise of the area of KM 'has coincided with the development of the global knowledge based economy in which emphasis has been shifted from traditional factors of production, namely capital, land and labour, to knowledge' (Jasimuddin, 2008). Superior knowledge is a very important factor (e.g. NPD, new technologies, new designs, higher efficiency, higher quality, etc.). Furthermore, knowledge is perceived to be intellectual capital (IC) and quite as important, if not more so, than physical assets and financial capital (Pons, personal communication, 2010).

A resource view on IC is offered (Bontis & Dragonetti, 1999), claiming that IC is '…any factor that contributes to the value generating process of the company and is, more or less directly, under the control of the company itself.' IC is sometimes also described as an asset (Liebowitz & Wright, 1999): 'a cost incurred in the present, which will provide an anticipated benefit by either generating a future cash flow, or avoiding a future cash outflow.' But IC and knowledge (management) are hard to measure. Internal measures of KM activity are often the frequency with which a knowledge repository is accessed and the extent to which it is augmented over time (Coakes & Bradburn, 2005). In general there is no consensus on the measure to use. For most practitioners it seems less important to measure the IC, as to ensure that knowledge is shared and distributed within the company. So, what can be done to support the distribution of knowledge within an organization? That is an open question, and part of this study explores it further.

There is an implicit premise within KM that increased knowledge somewhat automatically results in innovation, or at least that information enables innovation. But the premise that information begets innovation is by no means certain (Pons, personal communication, 2010).

Nonetheless knowledge is required for innovation. Therefore there is value in managing knowledge within organisations. It has to be assured that acquired knowledge (e.g. previous projects) is saved, and that the stored information can be extracted and reused for future projects. It could be used to enhance organizational learning in general, or to encourage innovation (Goh, 2005; Meso & Troutt, 2002). Another potential result is that time could be saved. Certain processes might not be necessary anymore during future projects, because they have been conducted in the past. Moreover the value of previous work is obviously higher, if the results (acquired knowledge) can also be used for future processes within the company.

Some processes in an organization can be classified as knowledge intensive; therefore KM might be valuable especially in those areas (Barcelo-Valenzuela, et al., 2008). A knowledge intensive process is characterised by the following attributes: Diversity of information sources and media types, variance and dynamic development, many process participants with varying expertise, Use of creativity, high degree of innovation, and some degree of decision-making.

By these criteria, many NPD processes are knowledge intensive, particularly those for a highly novel product, and perhaps less for routine design. NPD implies creativity, a high degree of innovation and certainly decision-making. Furthermore, variance and dynamic development and many process participants with varying expertise are part of NPD processes as different departments are usually involved. Thus KM is potentially especially valuable for NPD projects.

2.5 ISSUES WITH KNOWLEDGE MANAGEMENT

There are three major issues with KM as it currently stands. These are its unproven nature, potential stifling of real creativity and implementation difficulties.

Unproven nature of KM

KM assumes causality between knowledge capture and the success of an organization. Meso and Troutt recognized the importance of knowledge: 'It is now widely accepted that knowledge has strategic significance to the sustainable competitive position of a firm' (Meso & Troutt, 2002). Others assume that KM is the next likely source of competitive advantage (Goh, 2005). But those are assumptions and opinions, not facts. The issue is that there are few empirical studies that definitively show causality from implementing a KM programme to organisational success.

Stifling real creativity

It is possible that KM is only a fad that will pass. One of the fundamental tenets of the knowledge management movement is that the successful management of organizational knowledge will prevent firms from 'reinventing the wheel' (Newell, Scarbrough, Swan, Robertson, & Galliers, 2002). But thinking in new directions and being innovative are the basis of NPD. Possibly there is a danger that KM decreases the willingness to think outside the box. Also there is a risk that KM has too great an emphasis on managing the commodity of knowledge than managing the people (Smoliar, 2003).

Implementation difficulties

Selecting the KM strategy depends on the different purposes, the resources available, and the preferences of individual companies (Wu & Lee, 2007). Thus, no general framework for every company exists. Thus the situational (or contingency) variables that affect success or failure of KM programmes are not yet identified with any confidence in the literature, nor the relationships between them. This means that it is difficult for practitioners to implement KM processes to a given organisational situation, with confidence in the outcomes.

2.6 APPLICATION OF KNOWLEDGE MANAGEMENT IN THE NPD CONTEXT

2.6.1 DIFFERENT KNOWLEDGE MANAGEMENT STRATEGIES

Due to networked computers it is easy and cheap nowadays to codify, store and share certain kinds of knowledge. However, technology based practices might not be sufficient for successful KM, as KM is more about managing people and organizational culture (Smoliar, 2003; Tochtermann, 2003).Further, 'since KM as a conscious practice is rather young, executives have lacked successful models that they could use as guides' (Hansen, Nohria, & Tierney, 1999).

In the literature there are two different KM strategies: personalization and codification (Hansen, et al., 1999; MacMahon, Lowe, & Culley, 2004). There is the approach to codify and store knowledge in databases and make it accessible by anyone in the company, with an emphasize on the collection and organization of knowledge (MacMahon, et al., 2004). This is the *codification strategy*. Knowledge can also be carried and shared by persons. The person who acquires knowledge carries it and is expected to share it with colleagues in a communicative climate. Computers or even databases are used to identify and to find the expert on a particular topic within the company. This is called the *personalization strategy*. Codification is considered to be more formal, and personalization to be more ad hoc and informal (Boh, 2007). The following sections further define codification and personalization.

2.6.1.1 Codification Strategy

Basically the idea is to codify the knowledge a person has acquired: 'codification strategies involve the transformation of tacit knowledge into explicit knowledge' (Schulz & Jobe, 2001). The result is usually some kind of document that can be stored in the company's database. This is also known as 'person-to-document' approach. Once the document has been made accessible anyone in the company can use it without having to look for the particular expert first. The distribution of knowledge can be rather fast, however, it has to be made sure that knowledge can be found easily. Therefore people are necessary who maintain the databases and keep them as tidy as possible. Also it is important that the search of the database is as efficient and easy as possible. Companies that use this approach still communicate with one another; have telephone conversations or personal meetings (Hansen, et al., 1999). This is important, as it can be difficult to get all the required expertise on a certain issue out of a single document. Still, the main emphasis is placed on the codification of knowledge.

2.6.1.2 Personalization Strategy

Other companies prefer to focus on dialogue between employees rather than on codified knowledge in a database. The methods used are typically brain-storming sessions and one-to-one conversations. Technology, like computers are used to help people to communicate (MacMahon, et al., 2004). The idea is to have experts working on a project that communicate and exchange ideas during the whole problem solving process. The solutions that can be created here usually have greater depth and a higher degree of novelty and customization; they are tailor-made as it were. Networking computers are used to find the required experts. Technological means like e-mails, video-conferences, telephones are essential for the knowledge sharing processes. Those ways to communicate have to work perfectly, e.g. phone calls or e-mails from colleagues have to be answered as fast as possible (Hansen, et al., 1999). Firms that use this approach still codify some data, e.g. documents on certain projects are saved in databases, so employees can get basic knowledge on the topic and find out who has previously done work in the area. However, technology (e.g. computers) is used to help people to communicate (MacMahon, et al., 2004), but the emphasis is placed clearly on the personalization approach.

2.6.2 ACQUIRING KNOWLEDGE IN THE NPD CONTEXT

The knowledge acquired by the staff is very valuable for a company. Thus generally the objective is to extract that knowledge through KM and to store it for future projects.

According to Nonaka the individual's experiences, especially the variety thereof, are important because they 'crystallize into a unique perspective' (Nonaka, 1994) that would grow knowledge in the next part of the cycle. Also he asserted that knowledge was 'justified true belief' (Nonaka, 1994); meaning that a particular personal belief has been validated through experience.

Members of a NPD project team approve their assumptions and beliefs by conducting research and development which finally results in knowledge. The beliefs and assumptions can be true or wrong, either way people will learn during this process.

Nonaka held that knowledge was created by converting between tacit and implicit forms, in what he termed a spiral. He claimed that shared experiences ('socialization') were critical for creating tacit knowledge, 'externalization' used metaphor to express perspectives as tacit knowledge, 'combination' was the assembly of explicit facts, and that conventional learning ('internalization') just converted

explicit knowledge to tacit, hence 'SECI' which is the dominant model on knowledge creation (Pons, personal communication, 2010).

Nevertheless some researchers believe that SECI may not be the only or best way of looking at the subject and therefore not the perfect and ultimate solution (Glisby & Holden, 2003; Snowden, 2002). It is quite possible that different technical knowledge creating factors may be required.

Nonaka holds the belief that reflection is an important mechanism for knowledge creation (Nonaka, 1994). This approach is consistent with the present concept that intuitive knowledge is formed by making associations between schemata, and that reflection could improve the process (Pons, personal communication, 2010).

However the knowledge acquired by the individuals is the important basis of a learning organization. New product developments are highly innovative and usually imply a high degree of novelty, thus a lot of new knowledge is acquired through the whole process. Individuals have to be encouraged to share and to contribute their knowledge within a company. This is even more relevant for innovative engineering companies.

In an organization there are many ways for an individual to acquire knowledge (Pons, personal communication, 2010). This does not only include acquiring new knowledge during research and development, but one can also learn new things from co-workers. The means to find and access this knowledge depend on the KM strategy a company uses. For the codification strategy this means that staff can search databases to find documents that are relevant to current projects, but have been previously acquired by others. In that case there is no particular influence of personal factors, as anyone in the company has access to the files in the database. Trust and sympathy between donor and recipient are irrelevant here. These factors can play a role if the recipient needs further feedback on a document and requires a personal conversation with its creator. The most important factors for the codification strategy are the quality of the documents and the effort that is required to find what is needed.

This is very different in organisations that put an emphasis on the personalization strategy. The recipient must either know the donor or identify them. In case the recipient does not know who to approach, they can either ask other co-workers or search a database that lists experts in different departments for particular areas in every department. Once the potential donor is found, the recipient has to contact them and ask for their knowledge. Many factors can then influence the knowledge sharing process, such as trust, the relationship between donor and recipient or time.

2.6.3 SHARING KNOWLEDGE IN NPD

Knowledge-making is not always a private cognitive process. It often happens that learning occurs as a sharing process with other people. This is sometimes called social capital, but this is a quite imprecise and broad term with several different meanings (Akdere & Azevedo, 2005).

Usually sharing knowledge is considered desirable, but it is not easy to ensure within an organization. The question is 'what motivates people to transfer knowledge outside their work unit?' (Burgess, 2005). At this point, there is no specific answer yet.

A premise of knowledge sharing is that one person (recipient) is willing to ask for knowledge and another person (donor) is willing to share it (Pons, personal communication, 2010). This can be applied for both major strategies. For the personalization strategy this means that one person literally asks the other person directly for knowledge. If the donor is willing to share their knowledge, they can have meetings, discussions or the donor can even act as a mentor. For the codification strategy this means that the recipient is willing to look for codified knowledge. The donor must have been willing to codify their knowledge and to make it accessible (e.g. database, folder). The donor's reason to do so is mostly considered rather selfish. They could be keen to preserve the well-being of self and the group. They could also contribute to a particular project to point out their importance to the team. Moreover sharing their knowledge might be an attempt to ensure a successful outcome of a project, or the intention to split some of the work and therefore reducing their own workload. It is also quite possible that noble reasons motivate the donor to share knowledge, simply helping out a colleague for example.

The recipient's motivation to ask for knowledge can be the intention to establish a higher value within an organisation (project team); hence the ambition for power. It can also be the need for belonging to a group (Burgess, 2005). It is rather likely that the recipient requires certain information (knowledge) in order to ensure their success regarding a project or a specific task. Moreover the recipient can simply have a high interest in a particular area and thus be keen to learn. Another possible motivation could be social aspects as to team work. The reason a recipient might not try to acquire knowledge through asking the donor can be pride. Asking basically means showing a lack of knowledge in a particular area which can be interpreted as a weakness by others.

For personal sharing the willingness to share knowledge is strongly affected by the degree of trust between parties (Collins & Smith, 2006). Thus the relationship between the donor and the recipient plays an important role when it comes to the sharing of knowledge.

Knowledge sharing also depends on the personality of the employees. It has, for example, been found that people who are ambitious for power over others are less willing to share information while they are more likely to seek it on the other hand (Burgess, 2005). The agreeableness personality characteristic of the donor is likely to affect the willingness to donate knowledge; the openness personality of the recipient should be important in determining the willingness to require knowledge (Pons, personal communication, 2010).

Research also suggests that there sometimes is a 'norm of reciprocity' (Burgess, 2005) for knowledge sharing. It means that an individual who shares knowledge somehow expects this favour to be returned in the future. Basically this is the application of the 'one hand washes the other' principle. It is assumed that this occurs especially when two parties have a need for power and a rather low degree of trust between them.

It is critical for companies to ensure communication since knowledge sharing primarily occurs as a social activity. Thus it is important to make sure that interaction between employees (project team members) is supported. It is quite possible that employees share their knowledge at least once when a certain degree of trust has been established. But based on the outcome of doing so and the experiences within a particular organization their future behaviour as to sharing knowledge will certainly be influenced.

However these issues mainly address knowledge that is shared through the personalization strategy (see *2.6.1.2*). For the other important strategy described in literature, the codification strategy (see *2.6.1.1*), other issues have to be taken into account. In this particular case people have to be encouraged to codify their knowledge, hence to create documents such as presentations, and to store them in a database. The problems can be that people might find it difficult to codify their knowledge resulting in documents of low quality. It is quite likely that certain aspects of knowledge and expertise are difficult to put into a document, thus that the knowledge that can be shared with this method is not as deep as in the personalization strategy. Other serious issues could be inadequate company guidelines regarding how knowledge should be codified and stored resulting in poor motivation to do so.

3 METHOD

In order to answer the research questions, engineers and project managers of engineering NPD companies in New Zealand were asked to participate in an online survey and face-to-face interviews.

The investigation took a two-pronged approach. First, a survey was designed to identify the actual KM practices of people involved with NPD. Second, detailed interviews were conducted subsequently with select respondents.

Due to a rather low number of survey responses the survey was sent out to other countries (mainly Germany, but also Australia and the UK) to gather more valuable data. Also interviews were conducted with participants form these countries. This allowed a comparison between KM practices in New Zealand and Germany.

3.1 SURVEY

Based on the literature search a survey was created to address the research questions.

The survey was completed online. The survey was distributed to (a) firms known to be involved in engineering NPD, primarily NZ firms in this case, (b) University of Canterbury mechanical engineering alumni, (c) organisations that had previously been involved with final year projects in mechanical engineering and mechatronics engineering at the University of Canterbury, (d) members of the Project Management Institute (PMI) in New Zealand, Germany and Australia (via verbal presentation at meeting of local chapter, newsletters and website), (e) members of the Institution of Professional Engineers New Zealand (IPENZ) (via advertisement in newsletter).

Despite this exposure, it was difficult to obtain a large sample size. The survey was completed by 55 respondents within the time allocated for the maters programme. This sample size was disappointing, and required careful use of statistical methods to reliably extract meaning from the data, and even then limits the statistical power of the study. There is reason to believe that the issue may partly be that KM is not a topical subject for this target group of practitioners. This is based on the observation that a parallel research survey on team behaviour obtained a larger sample quicker: this despite being promoted concurrently through similar and in most case identical communication channels.

To ensure the statistical robustness of the survey answers, the STATISTICA® software was used.

The companies were broadly categorized into small (1-20 employees), medium (21-200 employees) and large (>200) company sizes. Of these,13 of the surveyed companies were small, 8 were medium sized and 28 were large. The biggest company had 140,000 employees, the smallest had one. Not every survey respondent answered this particular question.

The thinking behind the survey questions was to cover the various factors that other authors had determined or suggested as important for successful KM. Also, several speculative factors from our emerging theoretical model were included. Moreover, it was considered that association rules analysis methods would be used for this survey, hence, it was important to include questions for expected correlations.

The survey was categorized into groups to focus on different aspects related to KM and NPD. The following survey categories were used:

- *General questions as to knowledge*: In this category survey participants were introduced to the topic through questions like: 'What forms of knowledge are important in your opinion?', or 'Which parts of the knowledge management process do you use?' They got to pick all answers that applied; hence, suggestions were given to point out the direction of the survey and to give respondents that might not be familiar with the term knowledge management a basic understanding of the processes and practices involved. Particular questions were asked to address the importance of the topic for themselves and their companies, and to motivate people to complete the survey, for example: 'To what extent is your organization vulnerable to staff leaving and taking their knowledge with them?'

- *Your practices*: This section targeted the daily work of engineers and project managers by asking, for example, about the importance of KM for their jobs, the problems they see and the extent of KM success in their organization.

- *Personal sharing of knowledge:* This category particularly addressed personal knowledge sharing processes (personalization strategy) in an NPD environment. Participants were asked how their company encourages staff to share knowledge, as this was one of the research questions. Furthermore, people were asked to rate their willingness to share knowledge and to ask questions, but also their co-workers willingness to do so. Also they were asked what their reasons were to seek knowledge from others and what kept them from doing so. The answers to these questions were particularly interesting for the association rules analysis.

- *Organizational relationships:* In this category questions regarding the organizational culture were asked, for example, how respondents found the climate in their company and how personal relationships and trust influenced their willingness to ask questions and share their knowledge.

- *New product development:* As the significance of innovation was one of the research questions, this section targeted people's perception thereof. Also questions regarding NPD involvement and particular problems with NPD were asked.

- *Demographics:* This category included demographical questions, for example regarding the age or the gender.

It needs to be mentioned that this survey, like any other, cannot be completely free of bias, as it depends on the respondents to answer the questions correctly and truthfully. Also there is no way to ensure objective responses.

The survey could be completed online and included 50 questions (for details please see *Appendix A*).

3.2 INTERVIEWS

After the completion of the survey, face-to-face interviews (see *Appendix B*) were conducted to clarify interesting survey results, and to create a model for successful knowledge management.

The results of the online survey showed NPD companies used practices of the codification and the personalization strategy. The purpose of the interviews was to examine which strategy engineers and project managers involved in NPD prefer, and why. This was worthwhile to see if there was a tendency towards a particular strategy that might be more suitable for NPD projects.

Also the intention was to further explore how both strategies, codification and personalization, were applied in NPD organizations and what people found could still be improved.

3.3 ANALYSIS METHODS

3.3.1 ANALYSIS

The survey data was analysed to extract (a) summaries of frequencies, and (b) association rules. These methods were selected because of the qualitative nature of the data. The software tool used was STATISTICA®. ANOVA was applied to compare the proportions of responses and to examine the statistical significance of the results (if the p-value was 0.05 or smaller, the result was considered statistically significant).

3.3.2 INTERPRETATION

Summaries of frequencies are simply based on the frequency with which a response was given. In some cases the results were categorised, e.g. by New Zealanders and Germans.

Association rules analysis (ARA) provides the opportunity to explore the data and seek out hidden relationships in a posterior manner. The method, though commonly used for marketing analysis, is an uncommon research method. There are no known instances of it being applied to this type of application and therefore a brief description is provided below.

ARA is a powerful data-mining method that is used for qualitative data. It does not assume any prior distribution of results, nor does it require prior hypotheses. Instead it trawls through large data-sets seeking whatever associations may exist, whether or not the research has identified them beforehand. The statistical algorithm with ARA searches for co-occurrence of certain responses (items) with other responses. Perhaps surprisingly those responses do not need to be numerical, and therefore the method works for qualitative text responses. The output are rules with the structure if 'body' then likely 'head', where the body and head are items in the responses. The rules may be represented as tables or graphically.

It is similar to ANOVA in seeking statistically significant association, though with qualitative variables. Consequently it only identifies the more statistically important associations. This means that just because some response seems prominent in the *frequencies* (above), does not necessarily mean that it will meet the criteria for being a significant *association*. The associations show the co-occurrence of responses, not the absolute frequency of individual responses.

The two main measures of statistical significance for this method are support and confidence, and these may require some explanation:

- *Support* is the joint probability (relative frequency of co-occurrence) of items within the variables, i.e., separately for the *Body* and *Head* of each association rule. Thus *support %* of the time people who replied *body* also replied *head.* Or to put it another way, there is a *support* % chance of co-occurrence of body and head.
- *Confidence Value* is the conditional probability of the *Head* of the association rule, given the *Body* of the association rule. Thus for those who responded *body* there was a *Confidence Value %* chance that they also replied *head.* Or, for those who were *body*, there was a *confidence* % chance of them responding/doing *head*. Or there is a *confidence* % of *head* for those who had *body*.

ARA identifies the association between variables, not the temporal causality. However the strength of the association is not necessarily or even generally the same when the order of variables is reversed, i.e. the associations are asymmetrical. For example, it is possible that people who said X always also said Y. However of all those who said Y, only a few also said X. Thus the strengths of the associations can be used to infer precedence, even if not causality. Thus in the example the inference is that X always needs Y, but Y on its own does not need X.

4 RESULTS

4.1 SURVEY CHARTS AND INTERPRETATION

4.1.1 IN YOUR EXPERIENCE, IS KNOWLEDGE REALLY IMPORTANT FOR INNOVATION?

The results show that knowledge was considered important for innovation, see *Figure 1*.

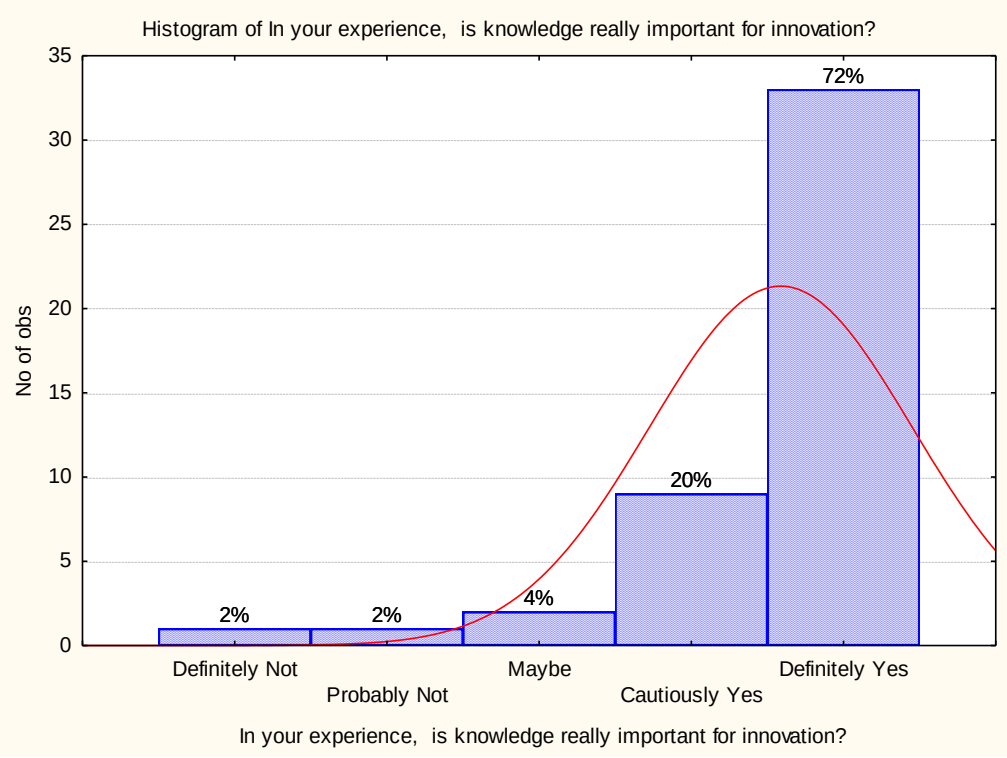

Figure 1: Importance of knowledge for innovation. Variables involved: Var. 116.

72% of the respondents found knowledge was definitely important for innovation. 20% replied 'cautiously yes'. No significant national difference was found. Respondents from both countries think that knowledge is important for innovation. See *Appendix C* for detailed survey analysis.

This result shows the high importance of knowledge for innovation, hence, for NPD companies. It is critical to manage this knowledge properly and benefit from previous work. The way a company deals with the knowledge that employees hold, could be vital for the NPD success.

4.1.2 *TO WHAT EXTENT IS KNOWLEDGE IN YOUR OPINION A COMPETITIVE ADVANTAGE OVER OTHER COMPANIES?*

On the whole the respondents found that knowledge is a competitive advantage over other companies (64% very great extent, 33% great extent), see *Figure 2*.

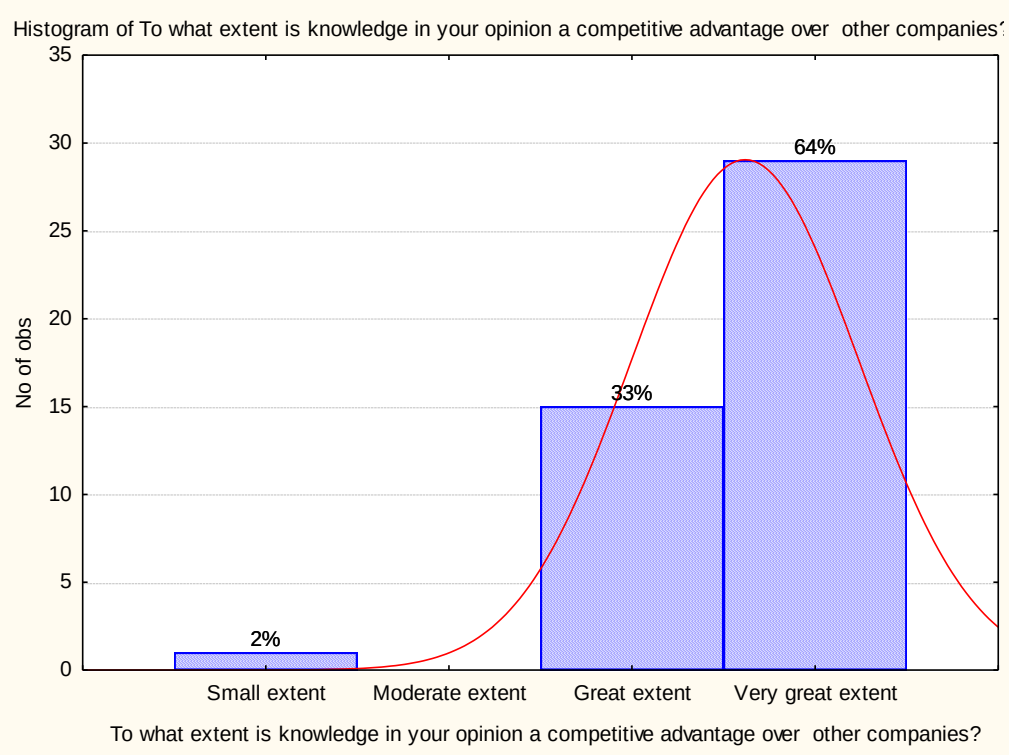

Figure 2: Importance of knowledge as competitive advantage over other companies. Variables involved: Var. 117.

Figure 3 shows that Germans tended to consider the importance of knowledge as a competitive advantage over other firms higher than New Zealanders. ANOVA showed that the difference is statistically significant (p=0.02), see *Figure 4*. This could indicate that knowledge itself is considered more valuable in German companies.

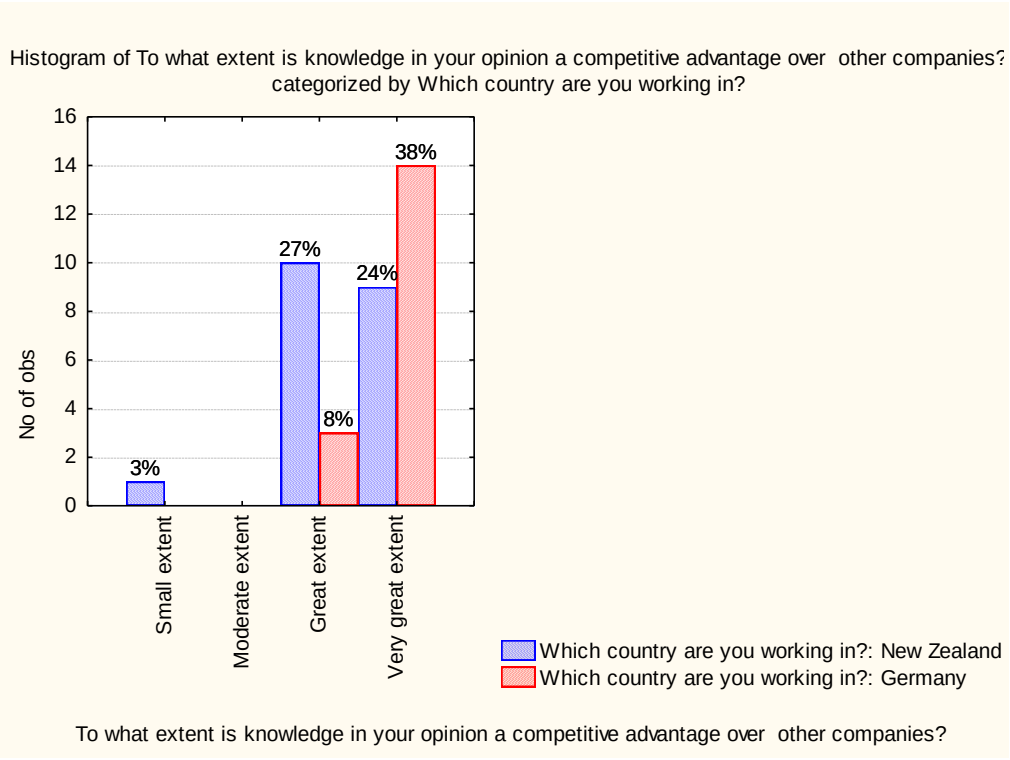

Figure 3: Difference between New Zealand and Germany regarding the importance of knowledge as a competitive advantage over other companies.

Figure 4: ANOVA result for the difference between New Zealanders and Germans regarding the importance of knowledge as a competitive advantage over other companies.

4.1.2.1 Association with KM success

An association between a high importance of knowledge as a competitive advantage ('very great extent') and great and moderate KM success was found, see *Figure 5*. Also there is an association between high importance of knowledge ('great extent') and moderate success. It is interesting to see that there only is an association between very high importance of knowledge ('very great extent') and great knowledge management success, while high importance ('great extent') could only be associated with moderate knowledge management success. Maybe this is an indication that only where there is very high awareness of the overall importance of knowledge successful knowledge management can be practiced.

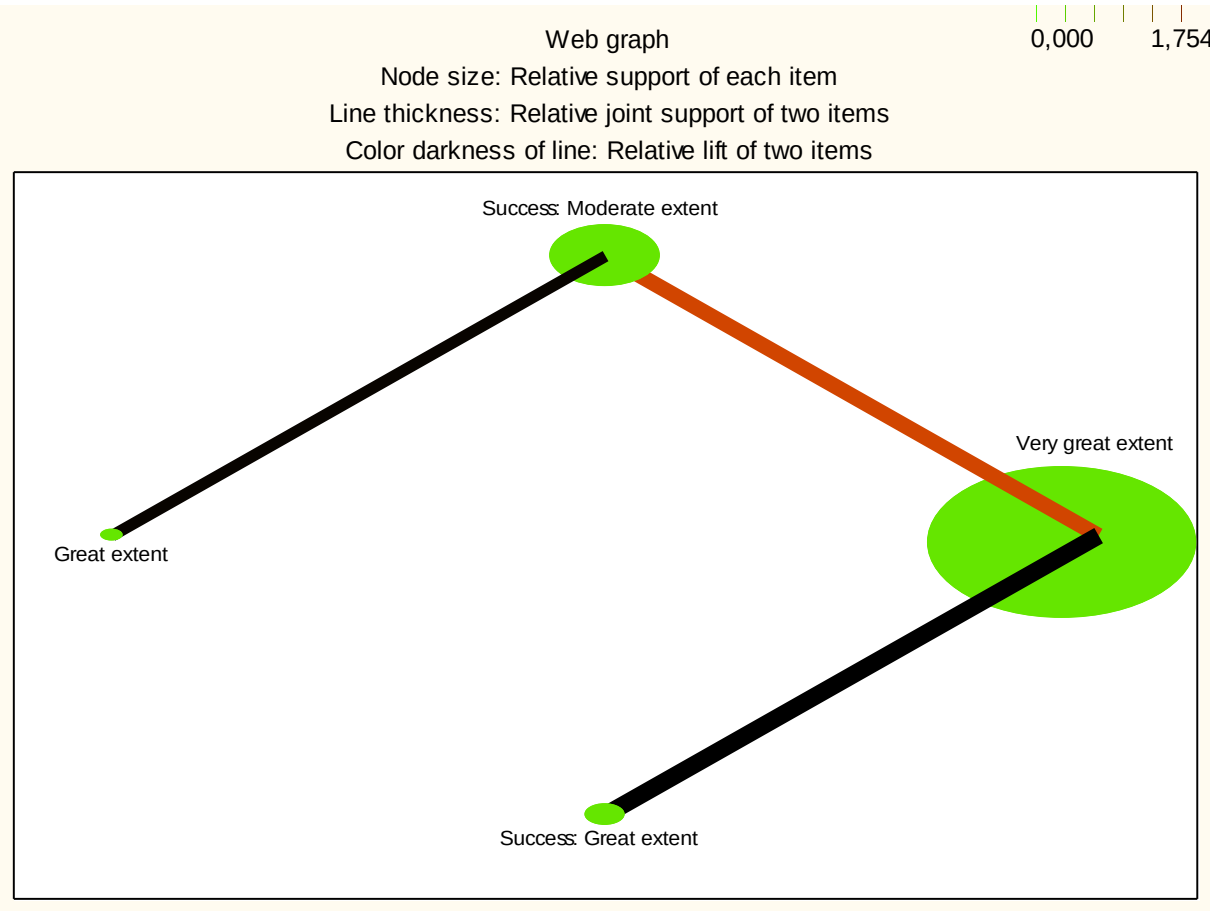

Figure 5: SAL for knowledge as a competitive advantage and KM success. Min. Support 0.1, confidence 0.1. Variables involved: Var. 117, Var. 28. Recogn: Success: To what extent is this knowledge management approach successful?; Comp Adv: To what extent is knowledge in your opinion a competitive advantage over other companies?

4.1.3 *TO WHAT EXTENT DOES INCREASED KNOWLEDGE AUTOMATICALLY RESULT IN INNOVATION?*

On the whole people tended to think that increased knowledge leads to innovation (57% great to very great extent). However the responses are not entirely positive. 41% of the survey participants found that this was only applicable to a moderate or small extent, see *Figure 6*.

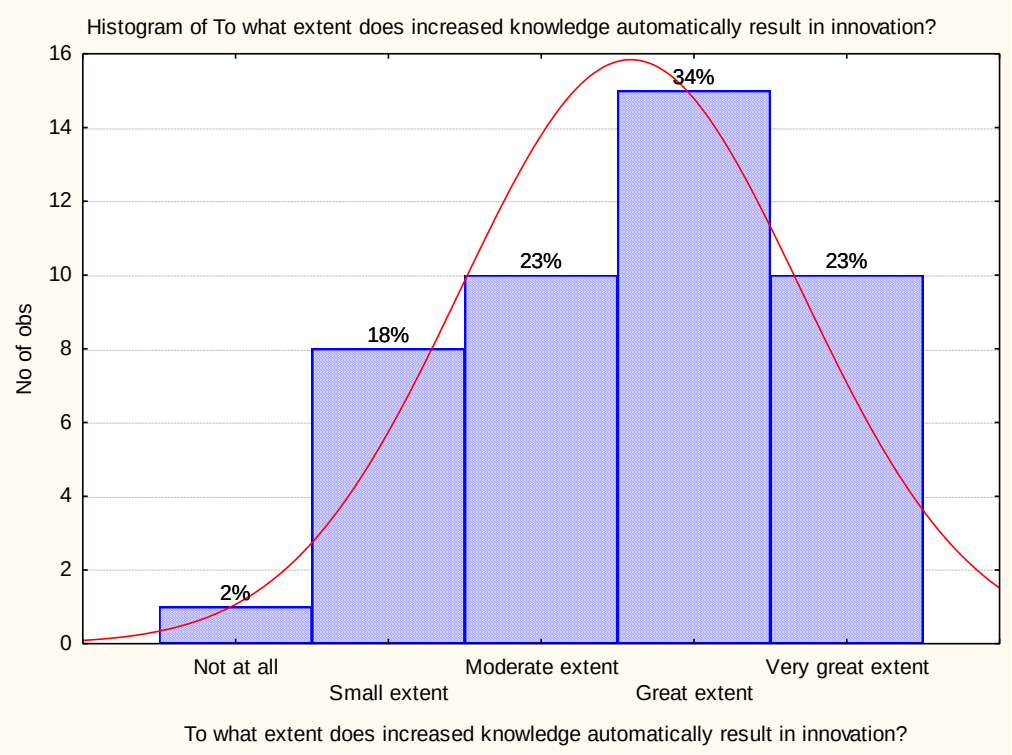

Figure 6: To what extent does increased knowledge automatically result in innovation? Variables involved: Var. 118.

A significant difference between New Zealanders and Germans could be found, see *Figure 7*. Germans tended to think that increased knowledge results automatically in innovation, while New Zealanders responded more cautiously. This shows again that the overall importance of knowledge for innovation might be perceived higher in German companies. ANOVA proves that the difference is statistically valid (p=0.00), see *Figure 8*.

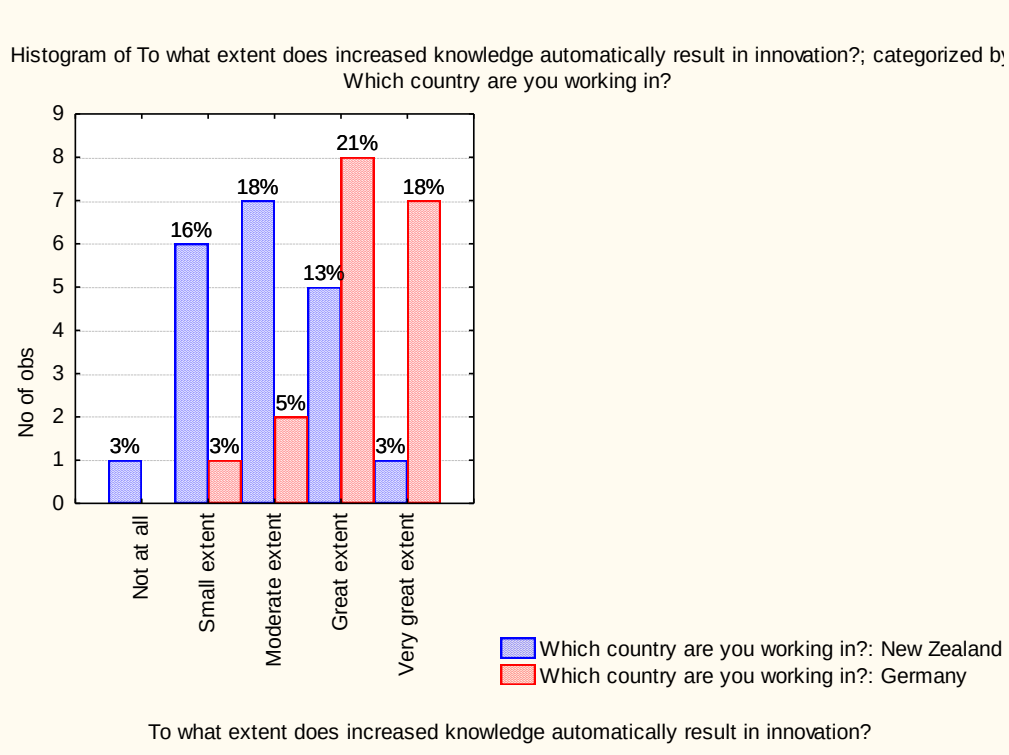

Figure 7: Difference between New Zealanders and Germans regarding the idea that increased knowledge would automatically result in innovation.

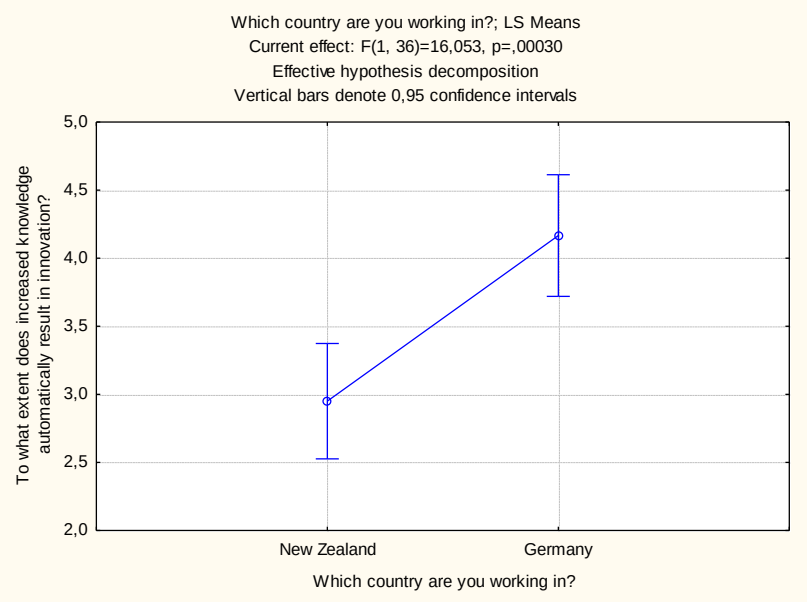

Figure 8: ANOVA result for the difference between New Zealanders and Germans regarding the idea that increased knowledge would automatically result in innovation.

4.1.4 *WHAT IS YOUR COMPANY'S KNOWLEDGE BASED ON?*

The results pointed out that the knowledge of an organization is primarily in the individual knowledge of staff, including the experience acquired during projects, and less so formal literature. This shows that knowledge management practices are important for companies in order to capitalize from these particular forms of knowledge. The knowledge from previous projects has to be saved and made accessible to staff. Also the individual knowledge of employees has to be shared within the company.

The knowledge of most companies is mainly based on knowledge that was acquired during previous projects and the knowledge of individuals, see *Figure 9*.

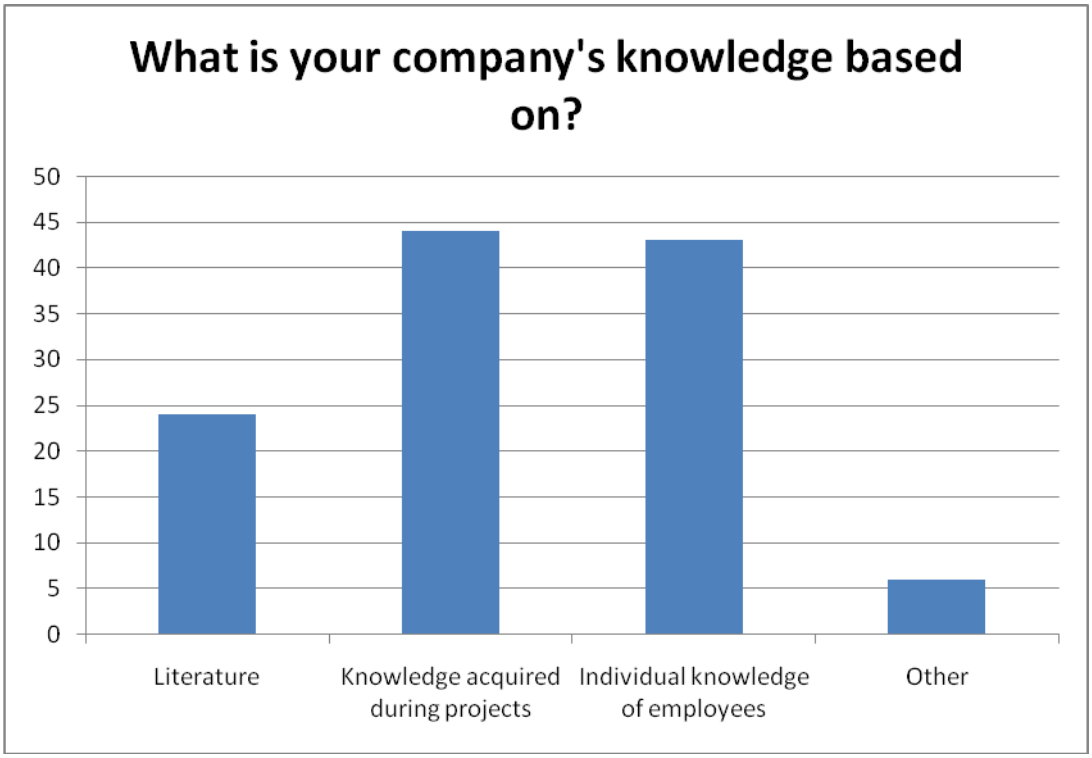

Figure 9: What is your company's knowledge based on? Variables involved: Var. 12-14, Var.16.

It is interesting to see that companies in New Zealand tended to base their knowledge more on literature than companies in Germany, see *Figure 10*. Knowledge that was acquired during projects and individual knowledge are found to be equally influential. The differences that were found regarding literature are statistically significant (ANOVA p=0.04), see *Figure 11*. See *Appendix C* for detailed survey analysis.

A possible reason for this result could be the smaller size of New Zealand companies compared to German companies. Thus, literature might be just more important, as the number of employees is

lower. The company size could also have an impact on the knowledge that can be acquired through completed projects, as this number is potentially lower in smaller organizations as well. It is also possible that geographical location of New Zealand has to be taken into account. While Germany is right in the middle of Europe with many industrialized neighbours, New Zealand is rather isolated and it might be more difficult to communicate with companies overseas to find out more about common practices and processes. By implications it might be relatively more important for New Zealand firms to make sure that their KM processes provide methods of aggregating literature.

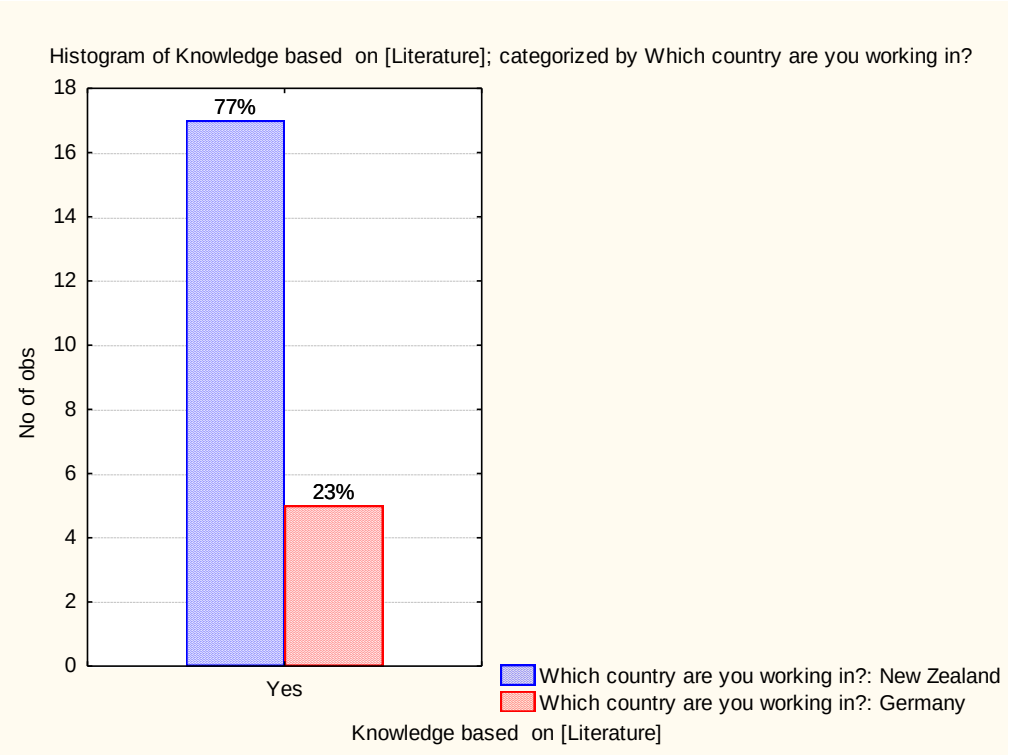

Figure 10: Difference between NZ and GER for literature as base for knowledge of a company.

Figure 11: ANOVA result for the difference between NZ and GER for literature as base for knowledge of a company.

4.1.5 *TO WHAT EXTENT IS YOUR ORGANIZATION VULNERABLE TO STAFF LEAVING AND TAKING THEIR KNOWLEDGE WITH THEM?*

Figure 12 shows that most companies are moderately vulnerable to staff leaving (44%) and taking their knowledge with them. But on the whole there is a tendency towards higher, rather than lower vulnerability. 80% of the respondents found that their company was vulnerable to staff leaving and taking their knowledge with them (moderate, great and very great extent). ANOVA showed that there was no statistically significant difference between companies in New Zealand and Germany. See *Appendix C* for detailed survey analysis.

It could have been expected that German companies are less vulnerable to staff leaving due to the bigger size of the companies, but according to the survey results, this is not the case. The explanation for this could be that the knowledge management practices in both countries in general are not as successful and hence, suddenly losing an employee could be a serious problem, as they would take their knowledge with them and leave a gap in their former organisation that has to be filled over time. This result suggests that staff knowledge, particularly tacit knowledge, is strategically important for the viability of NPD firms.

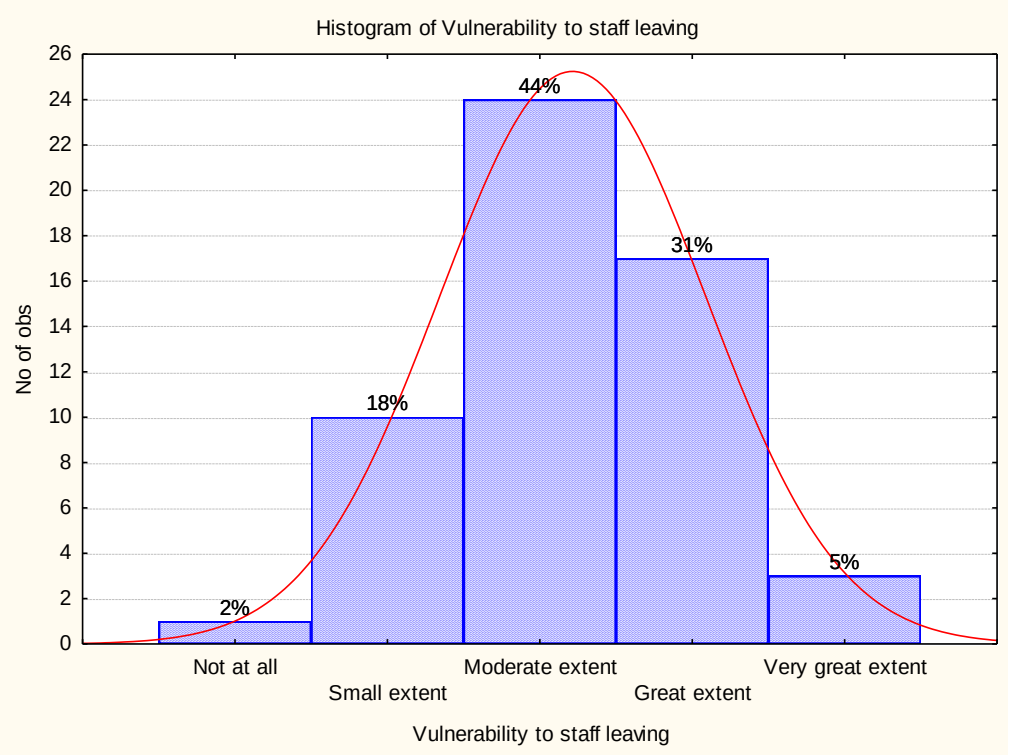

Figure 12: Perceived vulnerability to staff leaving a company and taking their knowledge with them. Variables involved: Var. 17.

4.1.5.1 Association with Knowledge Management Success

The data mining algorithm for sequence and association link analysis (SAL) showed a particular association between organisations with a moderate to great KM success being moderately vulnerable to staff leaving (95% of organisations with a moderate to great KM success were moderately vulnerable to staff leaving), see *Figure 13.*

The association between a great KM success and only a moderate vulnerability to staff leaving could indicate that successful KM can help to reduce this vulnerability of a company. The association between a moderate vulnerability and a moderate KM success could mean that even a moderate KM success is sufficient for a company to decrease their vulnerability to a moderate extent. It could also be a result of the large size of many surveyed companies. In spite of an only moderately successful KM, the sudden loss of employees and their knowledge can still be compensated. In general the term vulnerability might have been somewhat unclear and not sufficiently described to the survey participants. People could have different ideas of a high vulnerability. While for some survey respondents this could have meant that their small organization had to struggle to actually survive, it

could mean for others that certain tasks might be delayed and that other staff members had to take more responsibility to compensate the loss.

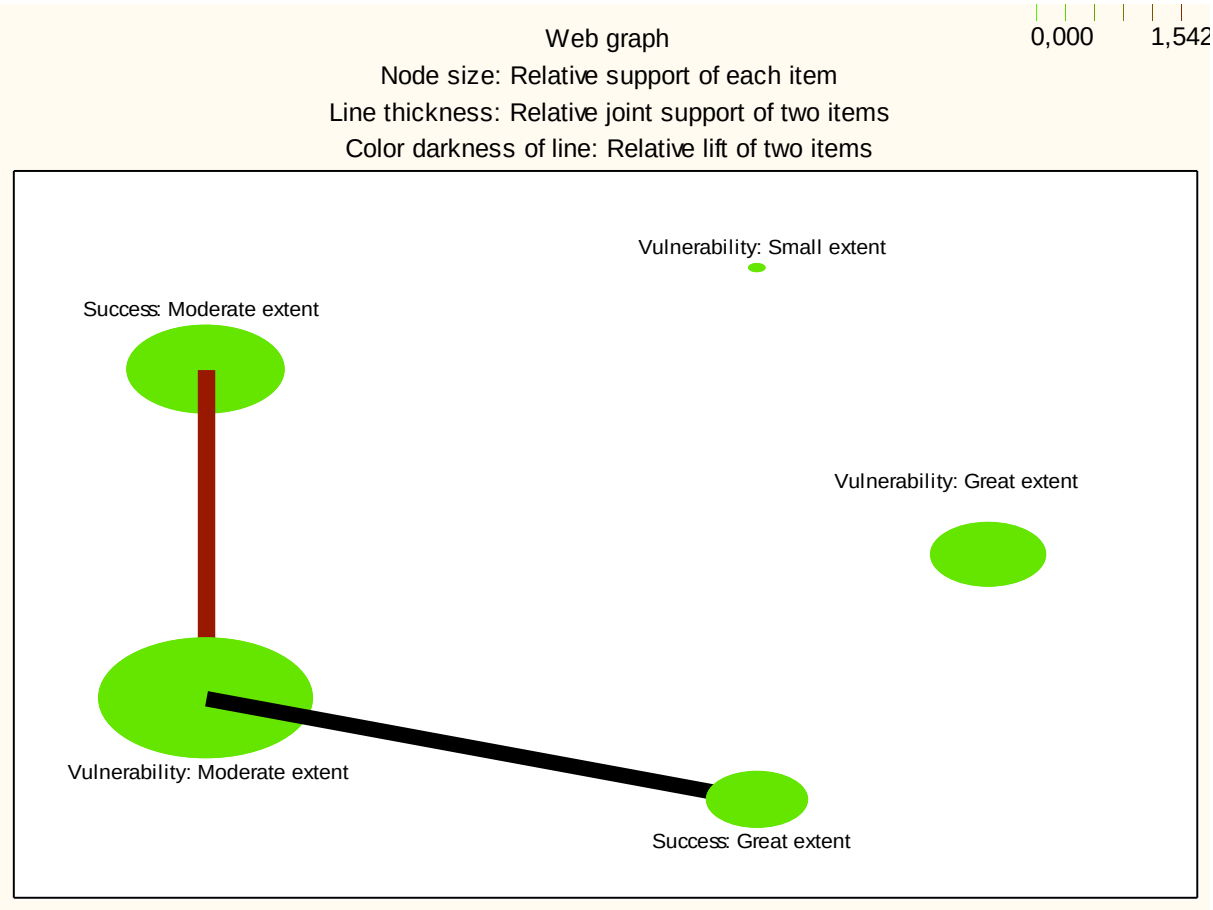

Figure 13: SAL for vulnerability to staff leaving and KM success. Min. support 0.1, confidence 0.1. Variables involved: Var. 17, Var. 28.

4.1.5.2 Association with particular KM processes

Through SAL it showed that companies with a moderate vulnerability to staff leaving are associated with the creation of a database and supporting a communicative work climate, see *Figure 14*. The analysis did not find an association between a low vulnerability and particular knowledge management processes. However it did show the association *between* the different methods. For example, a communicative culture was associated with having a database, meetings and presentations (but not particularly with workshops or interviews). The creation of databases was associated with regular meetings, supporting a communicative work-climate, regular meetings and the creation of presentations. Based on the survey results, the most common KM practices are the creation of a database, regular meetings, supporting a communicative work-climate, creating presentations and workshops.

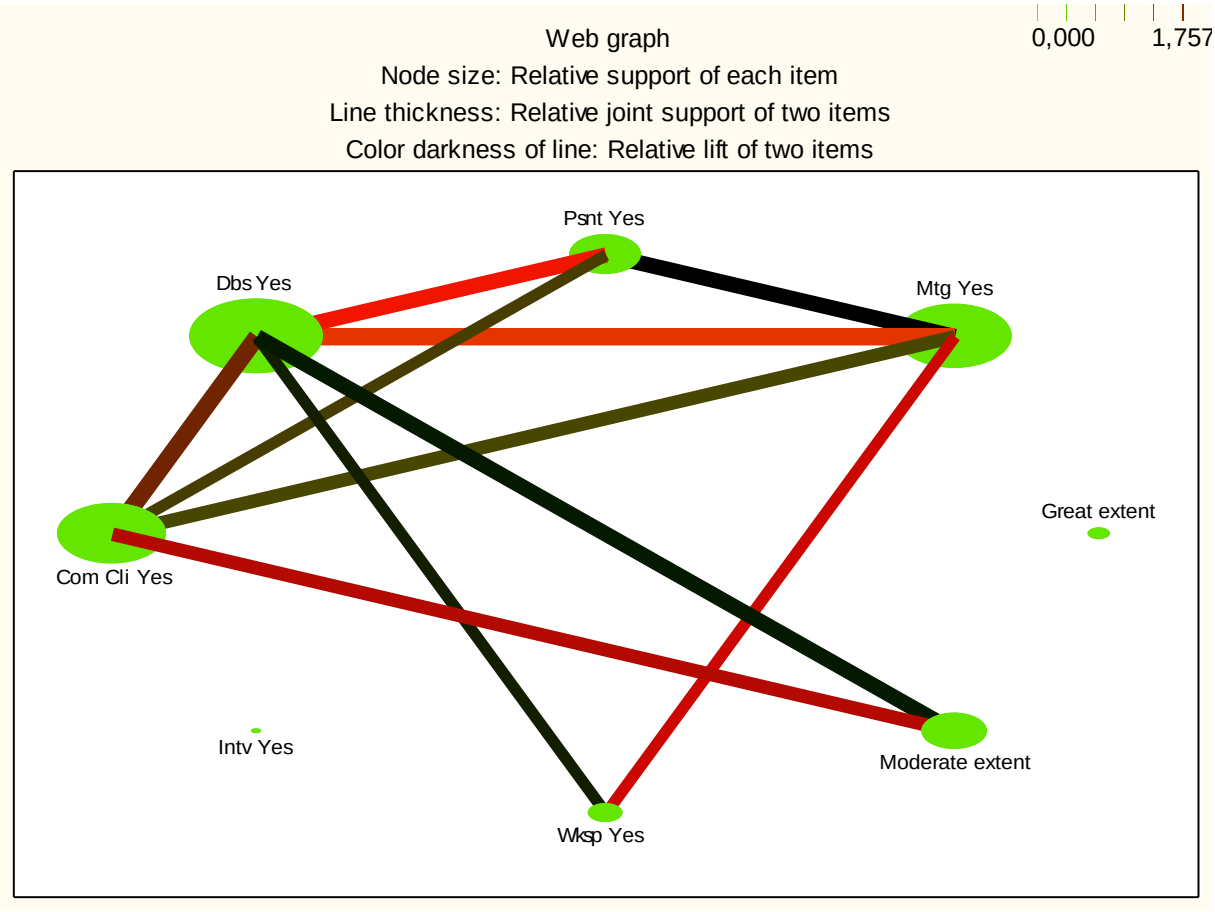

Figure 14: SAL for KM success and particular KM practices. Min. support 0.2, confidence 0.15. Variables involved: Var. 17, Var. 18-23. Recogn: Com Cli Yes: Supporting a communicative work-climate; Dbs Yes: Creation of a database; Psnt Yes: Creation of presentations on projects; Mtg Yes: Regular meetings for knowledge exchange; Wksp Yes: Work-shops; Intv Yes: Interviews with employees.

4.1.5.3 Association with accessibility of knowledge

SAL showed that companies with a moderate vulnerability to staff leaving could be associated with difficulties regarding finding stored knowledge, see *Figure 15*.

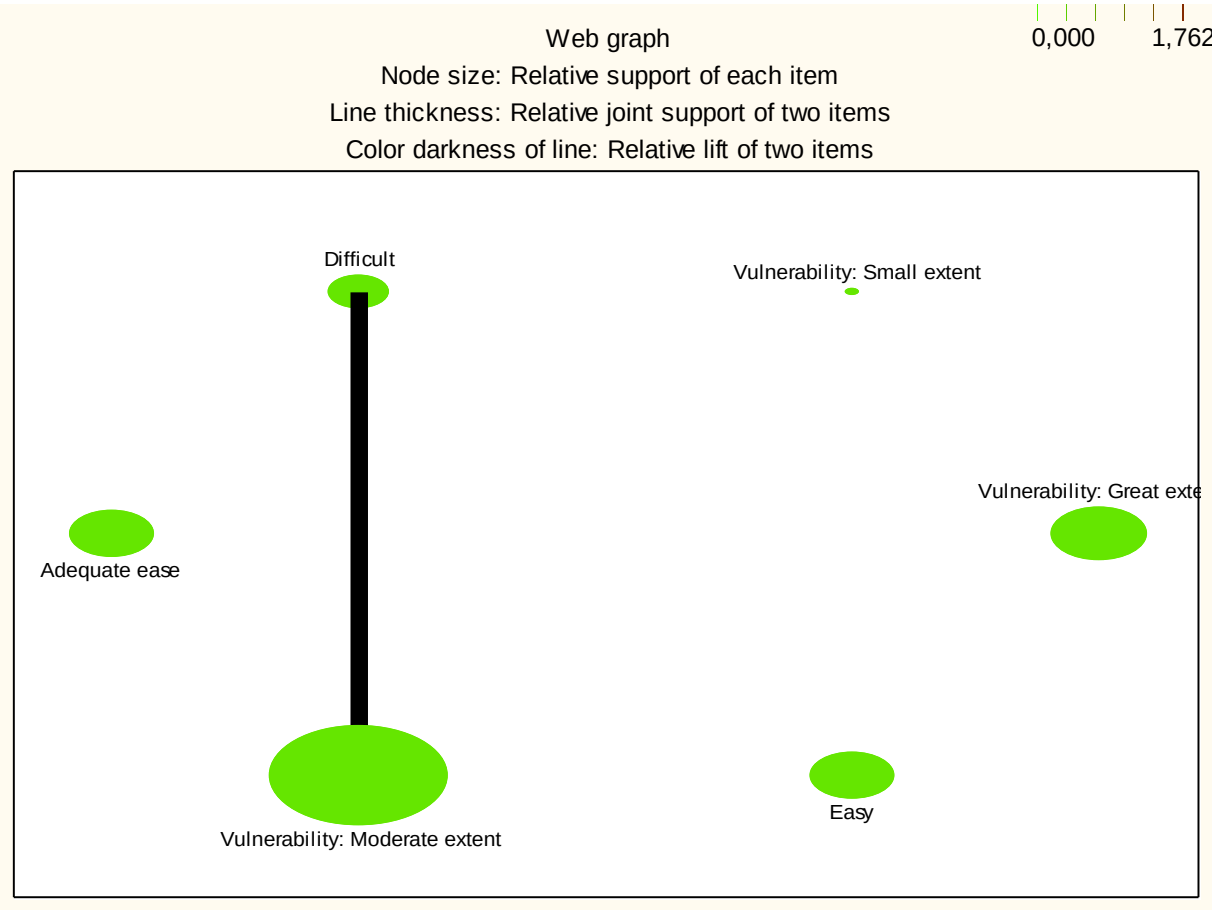

Figure 15: SAL for vulnerability to staff leaving the company and the accessibility of knowledge. Min. support 0.1, confidence 0.1. Variables involved: Var. 17, Var. 37.

It is possible that people rated their company's KM approach only moderately successful, because stored knowledge was hard to find.

However, one could have expected an association between easy access to stored knowledge and a low vulnerability to staff leaving, but this was not observed. The accessibility of knowledge alone does not guarantee successful knowledge management. It is by no means certain that the stored knowledge provides the required depth and quality. Moreover there might be forms of knowledge that are hard to be stored and therefore make the loss of an experienced valuable employee still severe. These forms of knowledge could include intuitive knowledge and experience with customers. Also a company can still be vulnerable to staff leaving as a particular staff member might have good connections to

customers and competitors or just provide many vulnerable ideas as a result of their expertise. Thus, even with properly saved *previously* acquired knowledge, losses for the company might occur in the future due to that loss.

4.1.6 *WHICH PARTS OF THE KM PROCESS DO YOU USE?*

The most common KM practices that are used in NPD companies are regular meetings, the creation of a database and supporting a communicative work-climate, see *Figure 16*.

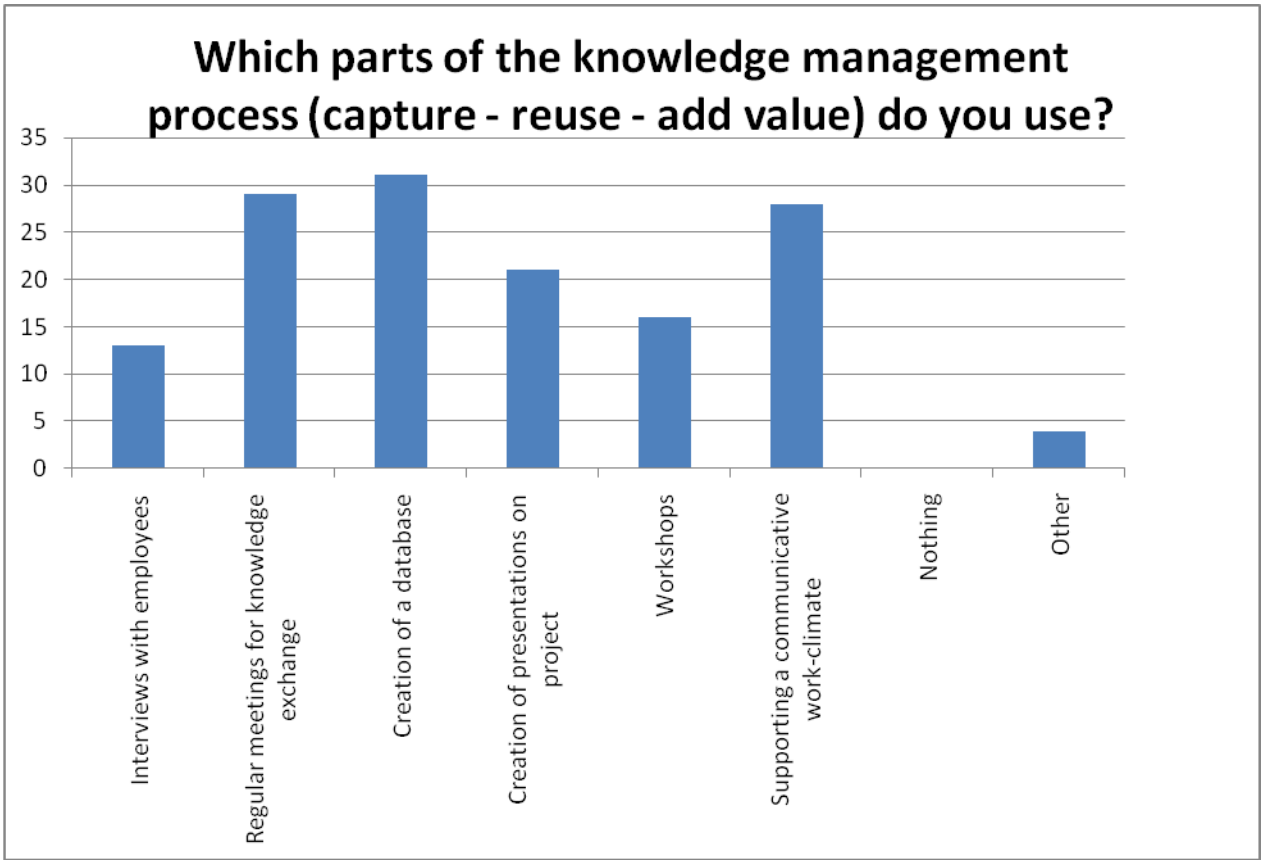

Figure 16: Which parts of the KM process do you use? Variables involved: Var.18-24, Var.26.

The results of a comparison between companies in New Zealand and Germany showed that the practices in both countries are rather similar. However, workshops and interviews with employees are more common in German organisations while a communicative work-climate is supported more in New Zealand. ANOVA proved that only the difference regarding workshops is statistically significant (p=0.06), see *Figure 17* and *18*. Using workshops as a KM strategy might be more common for bigger

companies, thus this could be the reason why a difference between both countries could be found here. The results for interviews with employees were close to being significant (p=0.07), while the perceived support of a communicative work-climate in New Zealand companies was insignificant (p=0.21). No survey participants from New Zealand or Germany found that their company was not doing anything regarding knowledge management. See *Appendix C* for detailed survey analysis.

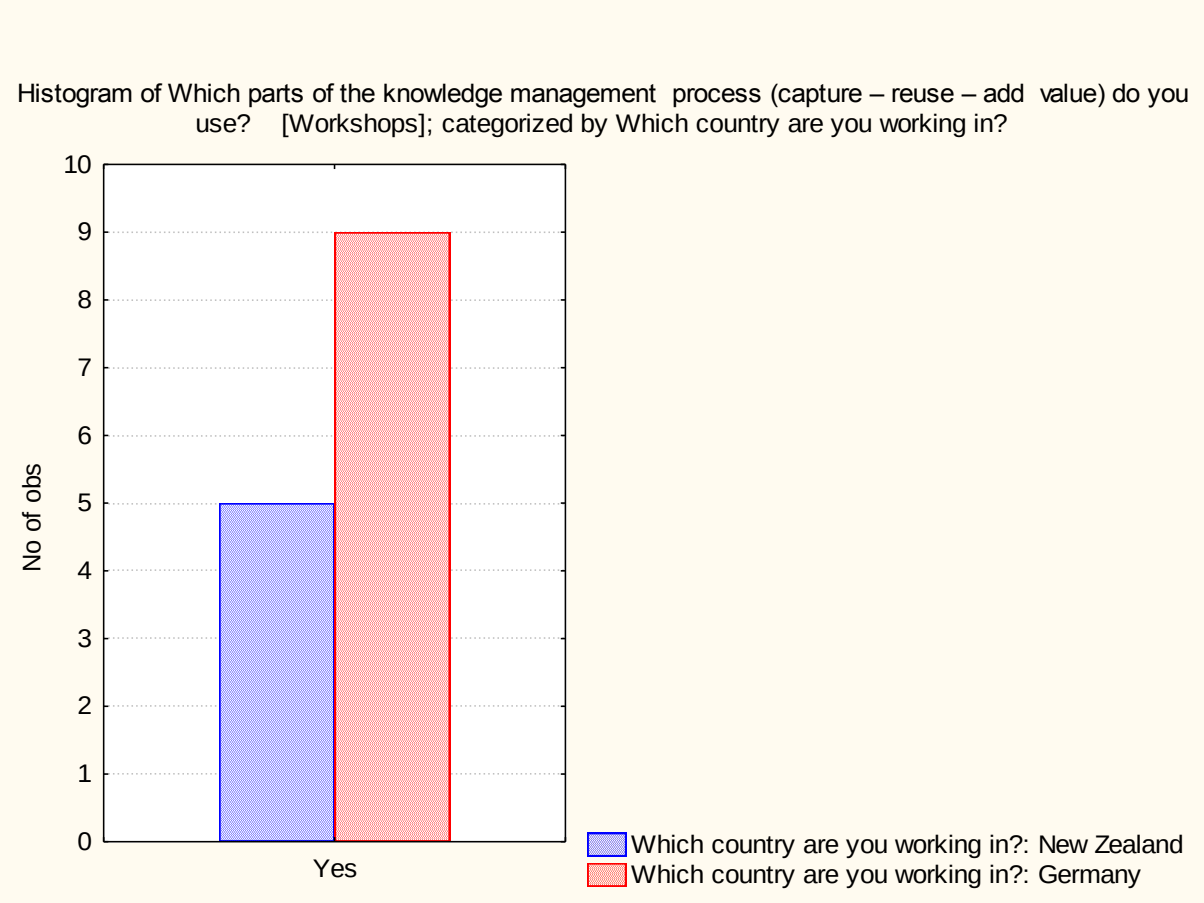

Figure 17: Difference between New Zealand and German companies regarding the use of workshops as KM process.

Figure 18: ANOVA result for the difference regarding the use of work-shops as KM process: (a) all responses, (b) between NZ and GER.

4.1.7 *TO WHAT EXTENT IS THIS APPROACH SUCCESSFUL?*

On the whole the survey respondents felt that the KM practices in their organisations were rather successful, see *Figure 19*.

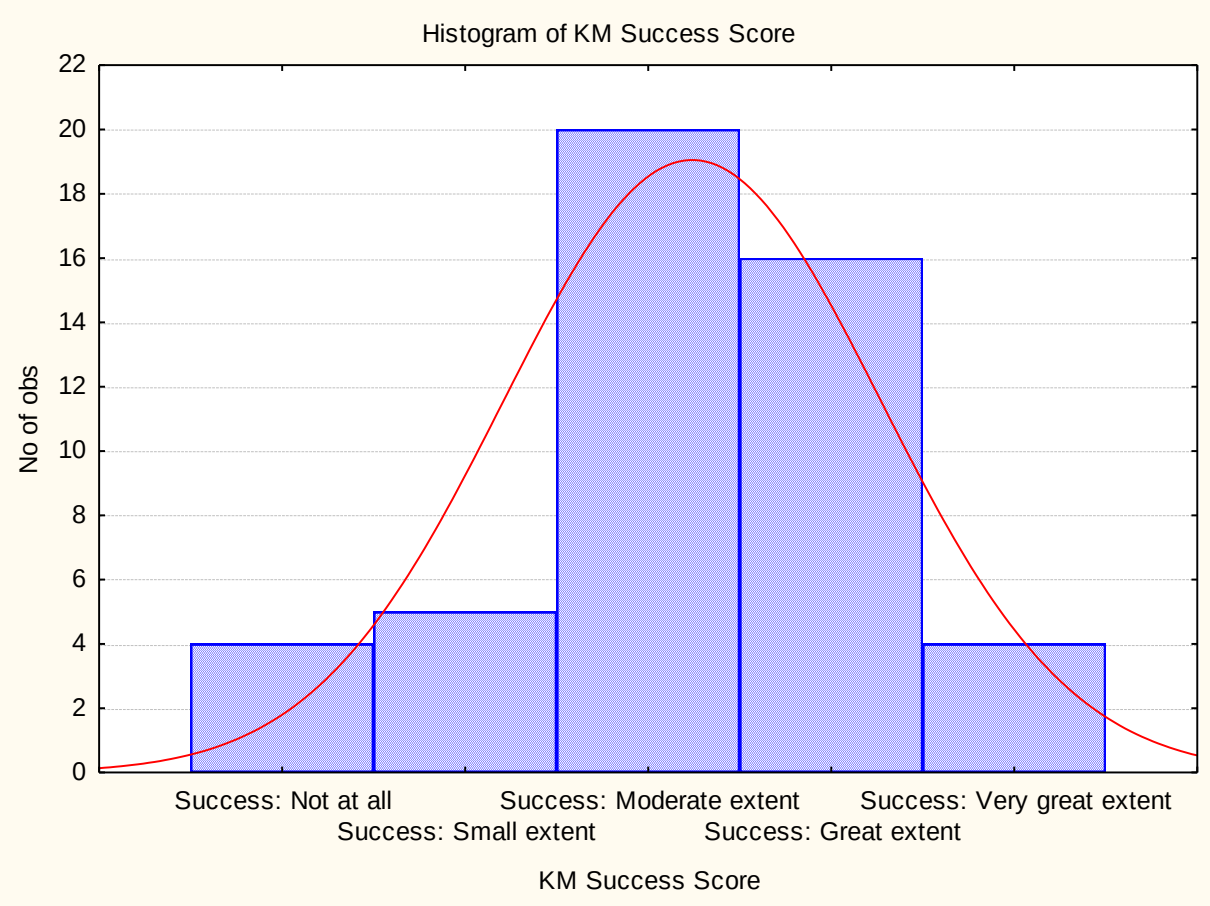

Figure 19: To what extent is your KM approach successful? Variables involved: Var. 28.

However, most people felt that only a moderate KM success was achieved. This suggests that it may be difficult to fully apply the potential of KM. GER has a mean success rate for KM that is slightly higher than NZ. However, this is not statistically significant (ANOVA result p=0.92). See *Appendix C* for detailed survey analysis.

4.1.7.1 Association of KM success and particular KM processes

The SAL was used to explore the associations between KM success and particular knowledge management practices. The results showed an association between a moderate KM success and the creation of a database. Great KM success was not only associated with the creation of a database, but also with regular meetings and the support of a communicative work-climate. This could mean that companies that want to improve their KM should use at least these three practices instead of just one of them. Also the results did show the association *between* the different methods. For example, a communicative culture was associated with having a database, meetings and presentations (but not particularly with workshops or interviews), see *Figure 20*.

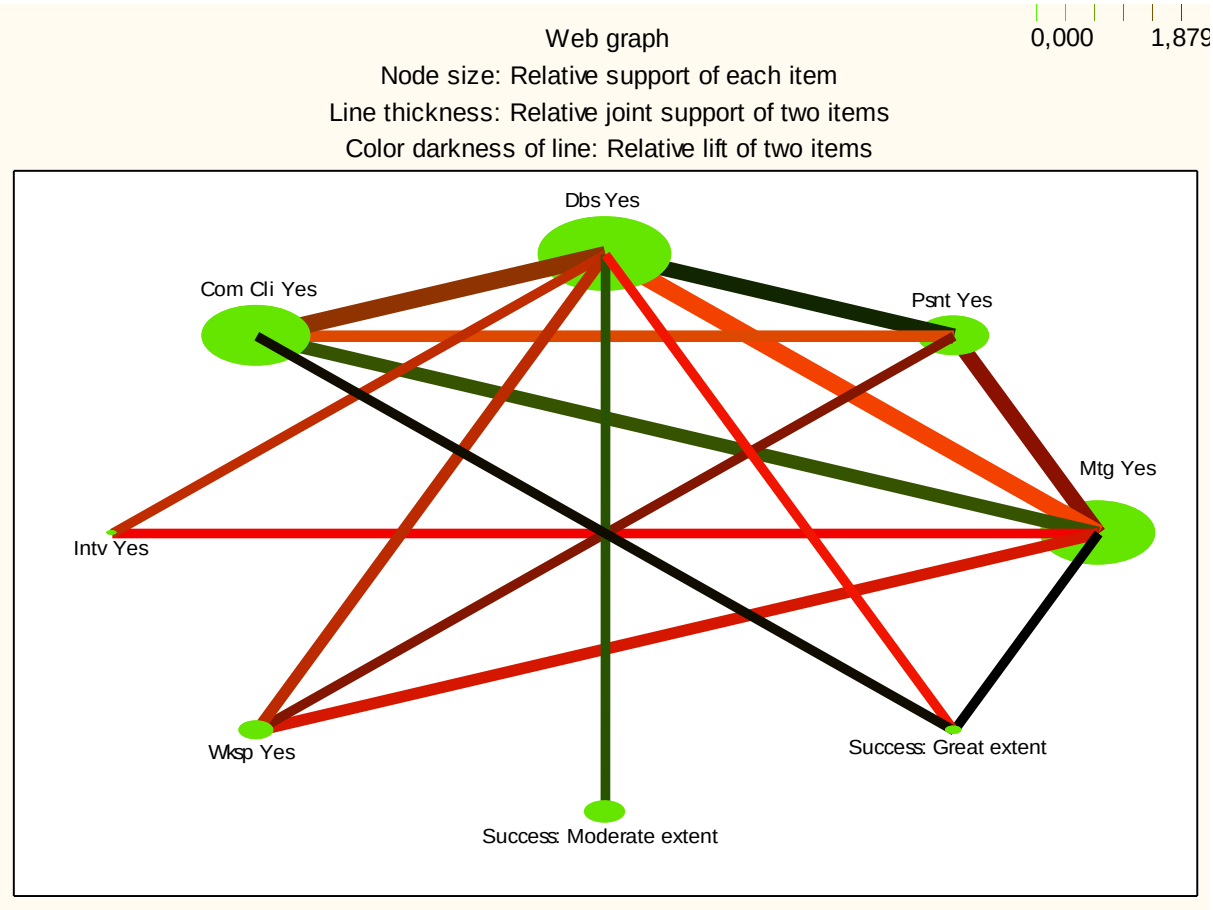

Figure 20: SAL results for KM success associated with KM practices Min. support 0.15, confidence 0.15. Variables involved: Var. 18-24, Var. 28. Recogn: Com Cli Yes: Supporting a communicative work-climate; Dbs Yes: Creation of a database; Psnt Yes: Creation of presentations on projects; Mtg Yes: Regular meetings for knowledge exchange; Wksp Yes: Work-shops; Intv Yes: Interviews with employees; Success: To what extent is this knowledge management approach successful?

4.1.8 *IF YOUR COMPANY DOES NOT FULLY USE KM PRACTICES, WHY IS THAT?*

Figure 21 shows that the most important reasons for employees not to fully use KM practices are too much effort and time to do so. Survey respondents also found that the culture does not encourage it and did not see the value in applying KM practices.

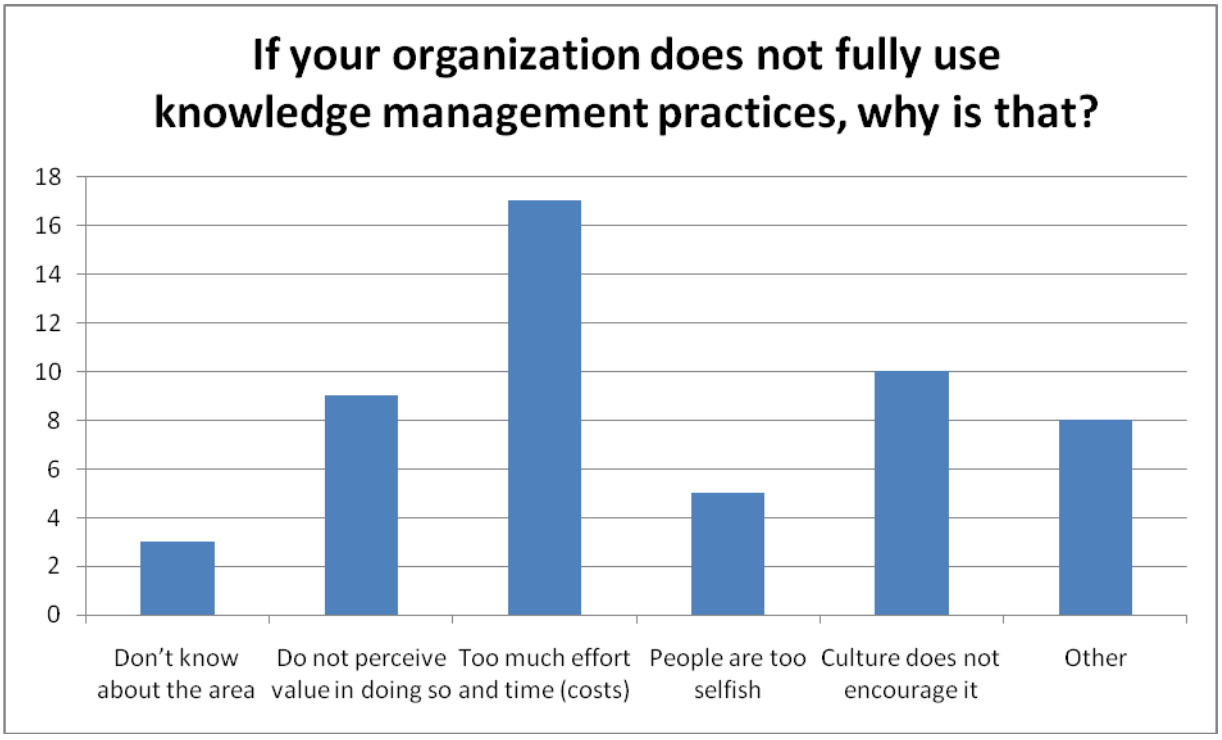

Figure 21: If your company does not fully use KM practices, why is that? Variables involved: Var. 29-33, Var.35.

Two major differences were found between respondents from New Zealand and Germany. New Zealanders were more likely to perceive only a low value in using knowledge management practices. But this difference is statistically insignificant according to ANOVA (p=0.1). Germans on the other hand tended to find that knowledge management practices were difficult to use, because people tended to be too selfish, see *Figure 22*. No New Zealander mentioned this to be an issue for their knowledge management. This result is statistically significant (ANOVA p=0.02), see *Figure 23*. Selfishness in companies was associated with the overall culture in a country. But maybe it could also be an effect that can be seen in bigger companies rather than in small ones. There might be a higher risk in big companies that people feel like they have to try to make themselves irreplaceable, while in smaller companies the feeling of working together and trying to reach the same goal might be stronger resulting in less selfishness among employees. A similar effect was seen when survey participants

found that their willingness to share knowledge within a work-group was greater than in the wider organisation, see *Figure 53* (section *4.1.20).*

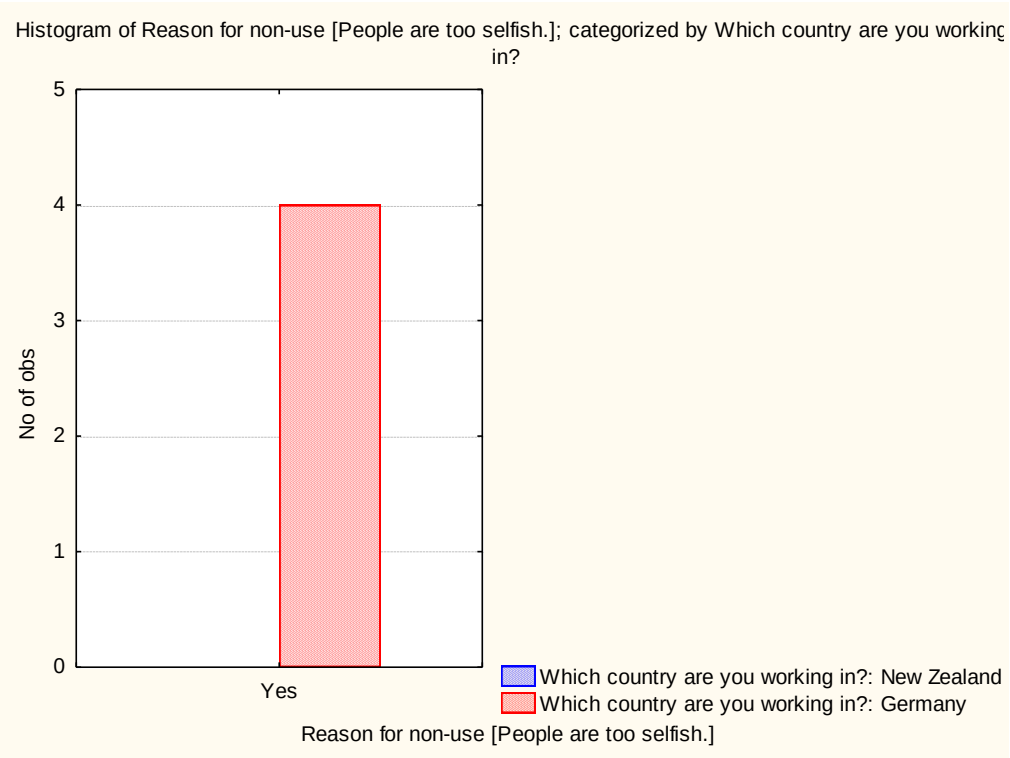

Figure 22: Difference between New Zealand and Germany regarding selfishness of people as a problem for KM.

Figure 23: ANOVA result for the difference between NZ and GER for selfishness as a KM problem.

4.1.9 *TO WHAT EXTENT DOES YOUR COMPANY FORMALLY MEASURE ITS INTELLECTUAL CAPITAL?*

Figure 24 shows that most companies tended to not measure their intellectual capital formally. 33% stated that they did not measure it at all. 40% only measure their intellectual capital rarely or sometimes. There could be different reasons for this particular result. Companies might find that formally measuring their knowledge was irrelevant. However, it is also possible that the methods are lacking, unknown, or too difficult to use.

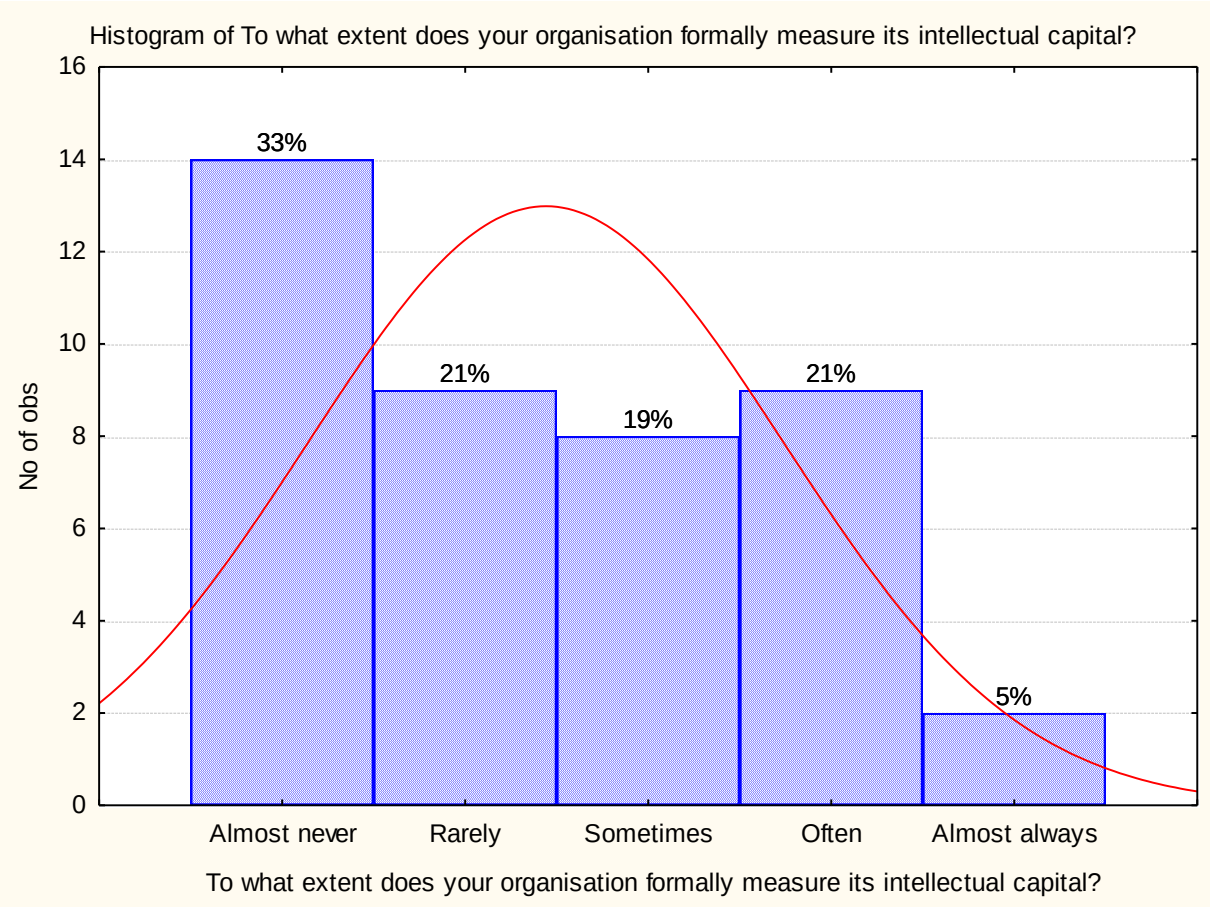

Figure 24: To what extent does your company formally measure its intellectual capital? Variables involved: Var. 36.

4.1.9.1 Association with KM success

The SAL results showed that a moderate extent of KM success can be associated with a low activity to formally measure intellectual capital (almost never), see *Figure 25*.

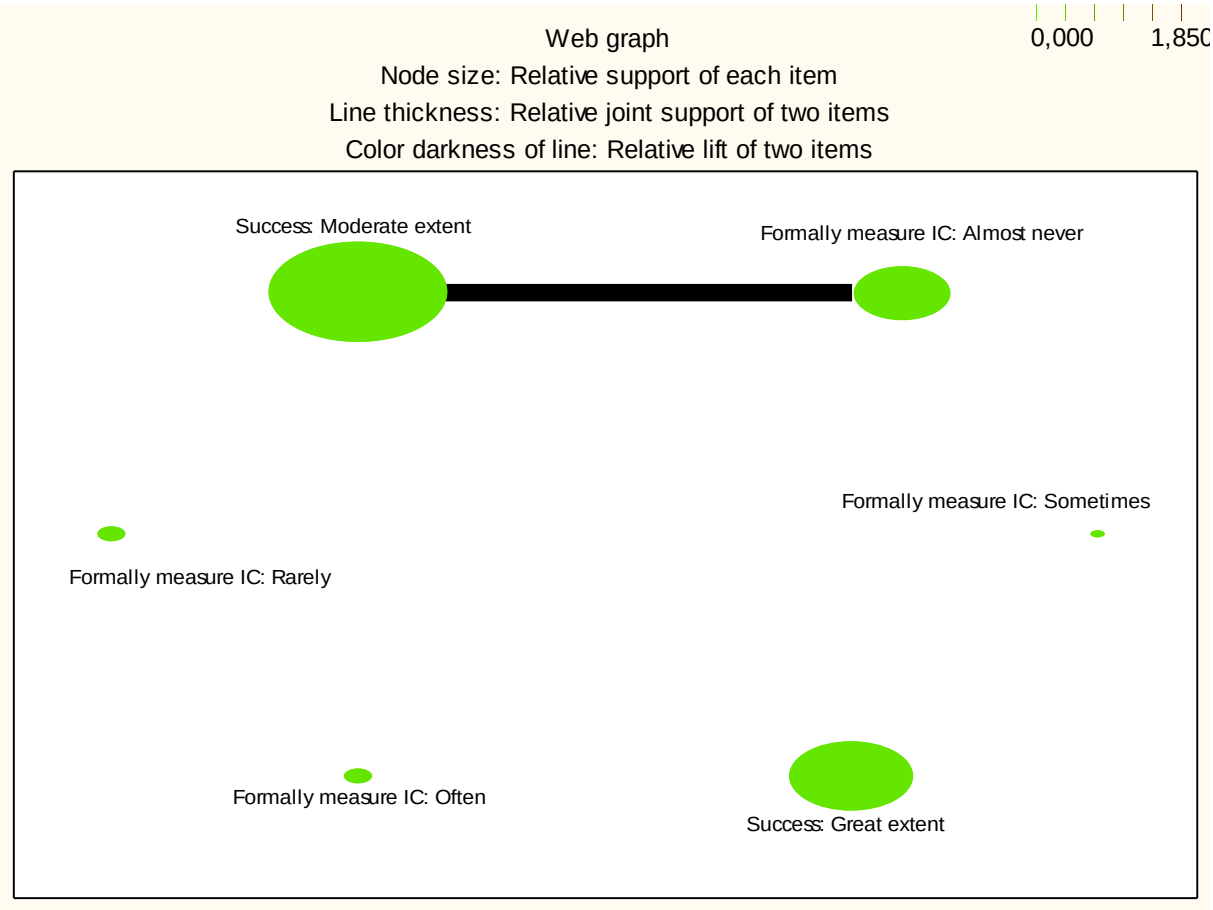

Figure 25: SAL results for KM processes associated with formally measuring intellectual capital. Min. support 0.1, confidence 0.1. Variables involved: Var. 28, Var. 36. Recogn: Formally measure IC: To what extent does your company formally measure its intellectual capital?; Success: To what extent is your knowledge management approach successful?

Two possible conclusions can be drawn from this. Almost never measuring IC could indicate a low awareness of knowledge management and a low perceived value of knowledge and intellectual capital resulting in unsatisfying knowledge management success. It might suggest that these firms could improve their KM by measuring their IC more often.

For the present it is assumed that poor IC measuring is no impediment to KM success, at least for moderate success. Furthermore there is no observed association between great KM success and IC measurement activities. Thus by implication, IC measurement is irrelevant to KM success. In order to

fully analyse the importance of formal IC measurement a survey with a higher number of participants will be required.

4.1.10 How important is KM for the successful completion of your job?

On the whole most people found that knowledge management was very important for their jobs (80% of the participants answered it was somewhat important to very important), see *Figure 26.* New Zealanders seemed to rate the KM importance slightly higher than German survey respondents, but it is not a statistically significant result (p=0.76). However, the results show that there is a dependency on KM in NPD companies.

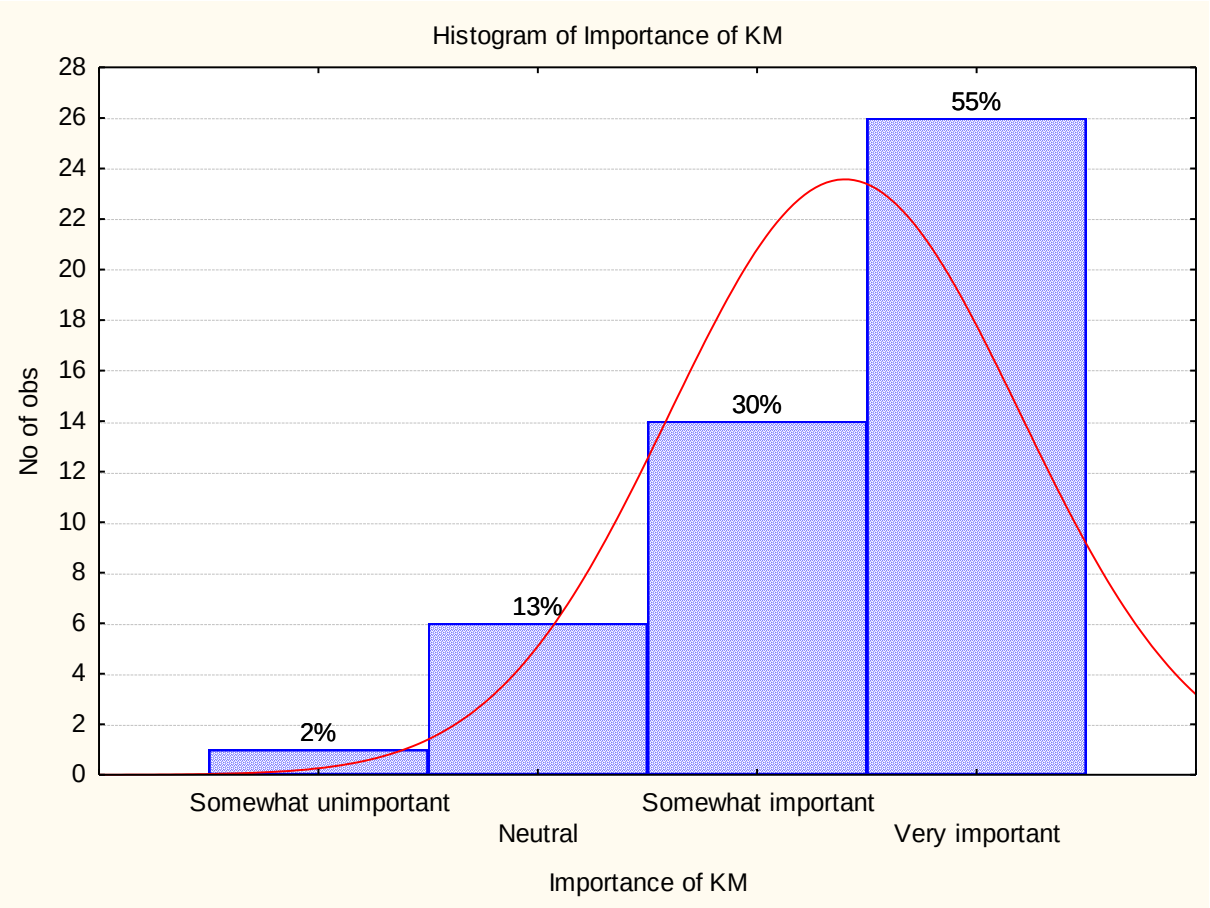

Figure 26: Importance of KM for the successful completion of work. Variables involved: Var. 41.

4.1.11 TO WHAT EXTENT DOES YOUR FIRM USE FORMAL KNOWLEDGE-CAPTURE PROCESSES?

Figure 27 shows that almost half of the respondents (49%) found that their company only uses formal knowledge-capture processes to a small extent. 26% think their organization uses formal knowledge-capture processes to moderate extent while only 25% rate the extent as high (great to very great extent). The comparison between New Zealand and Germany showed that New Zealanders tended to be more negative. But no statistically significant difference could be found (p=0.58). The question is, why do almost half of the surveyed companies only use formal knowledge capture processes to such a low extent? There are four different approaches to explain this:

1. Ignorance: could be solved through training.
2. Irrelevance: better methods need to be researched.
3. Unreliability: better methods need to be researched.
4. Lack of time: simpler and quicker tools need to be developed.

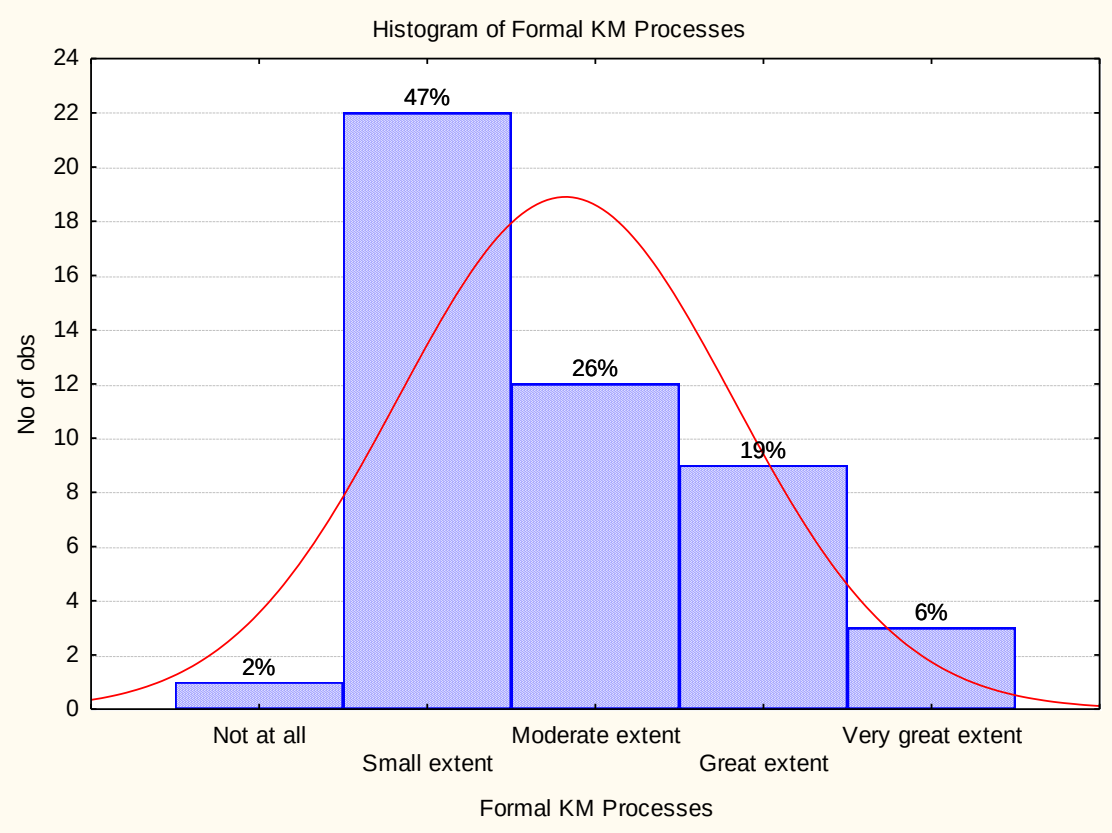

Figure 27: To what extent does your firm use formal knowledge-capture processes? Variables involved: Var. 43.

4.1.12 *What does your firm do to encourage people to share their knowledge?*

The most common practices in NPD companies to encourage employees to share their knowledge are the support of a communicative work-climate, active encouragement to share knowledge and regular meetings for knowledge exchange, see *Figure 28*.

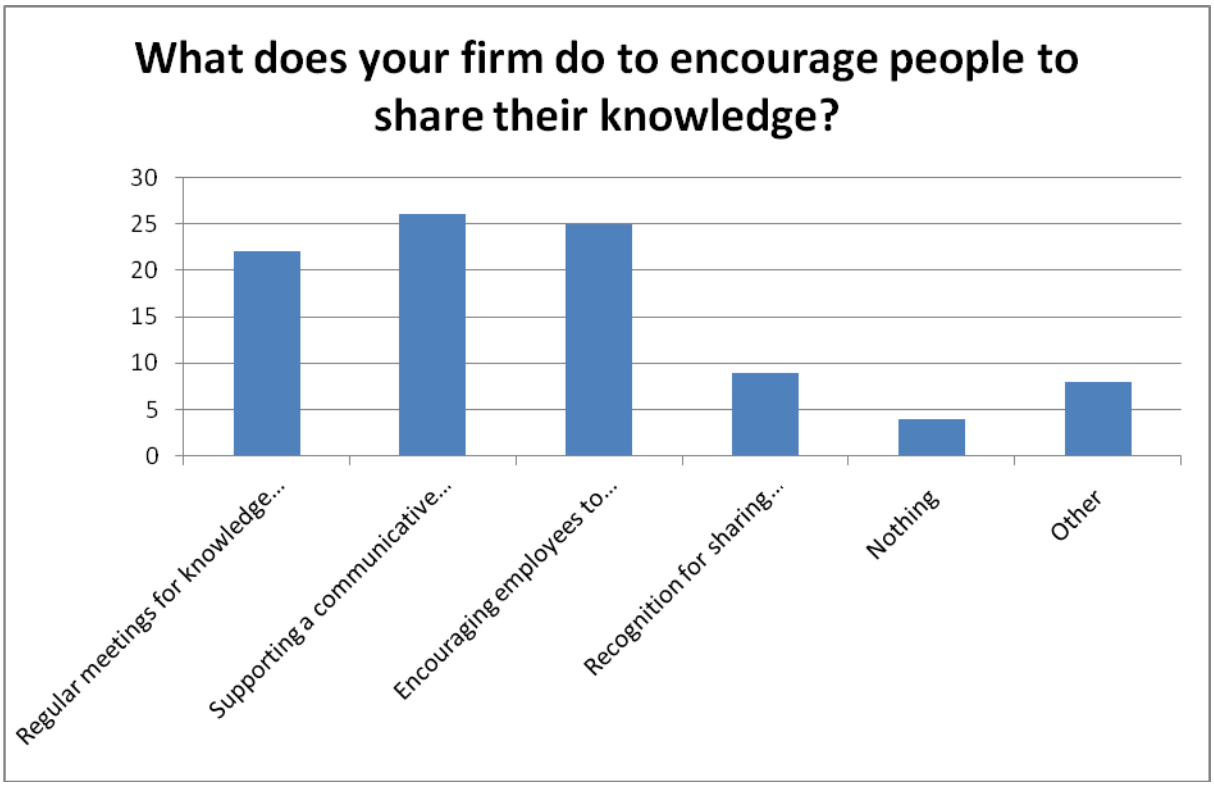

Figure 28: Different encouragement practices t for employees to share knowledge. Variables involved: Var. 44-47, Var.49.

On the whole regular meetings and recognition for sharing knowledge seem to be more common practices in German companies. The difference regarding regular meetings is statistically significant (ANOVA p=0.05), see *Figure 29* and *30*. The difference regarding recognition for sharing knowledge was found statistically insignificant (ANOVA p=0.11). See *Appendix C* for detailed survey analysis.

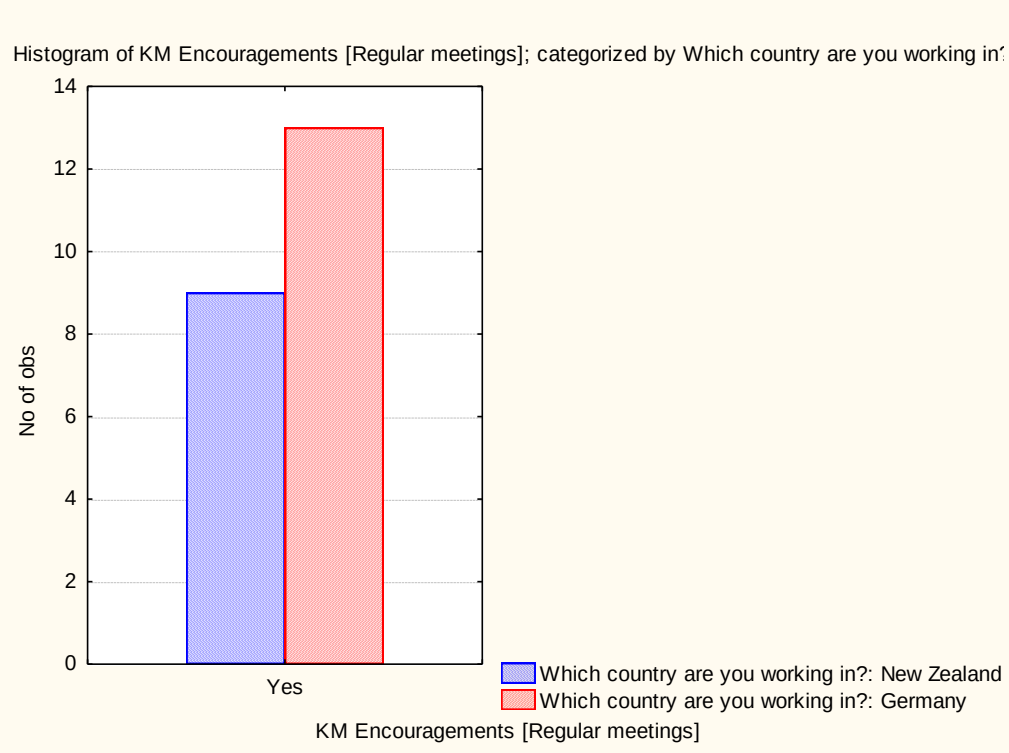

Figure 29: Difference as to regular meetings between New Zealand and German companies.

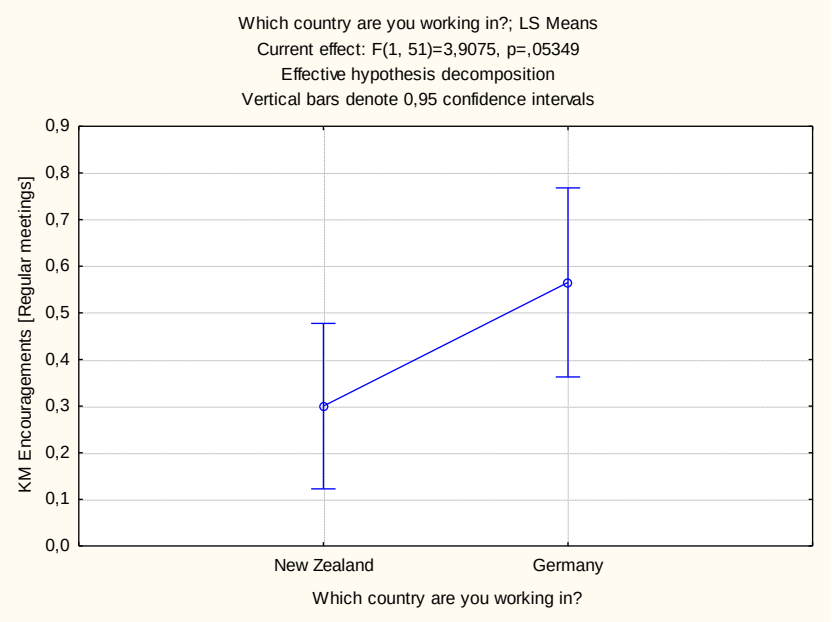

Figure 30: ANOVA result for the difference between New Zealand and German companies regarding regular meetings.

4.1.12.1 Association with KM success

The SAL results showed that companies with a moderate knowledge management success could be associated with the support of a communicative work climate, see *Figure 31*. Companies with a great knowledge management success do not only support a communicative work climate, but also actively encourage their employees to present ideas and knowledge and set up regular meetings for knowledge exchange. Also an association *between* these three different methods could be found.

Implications for practitioners are that KM success appears to require nor only a communicative work-climate, but also regular meetings for knowledge exchange and active encouragement of staff to share their knowledge.

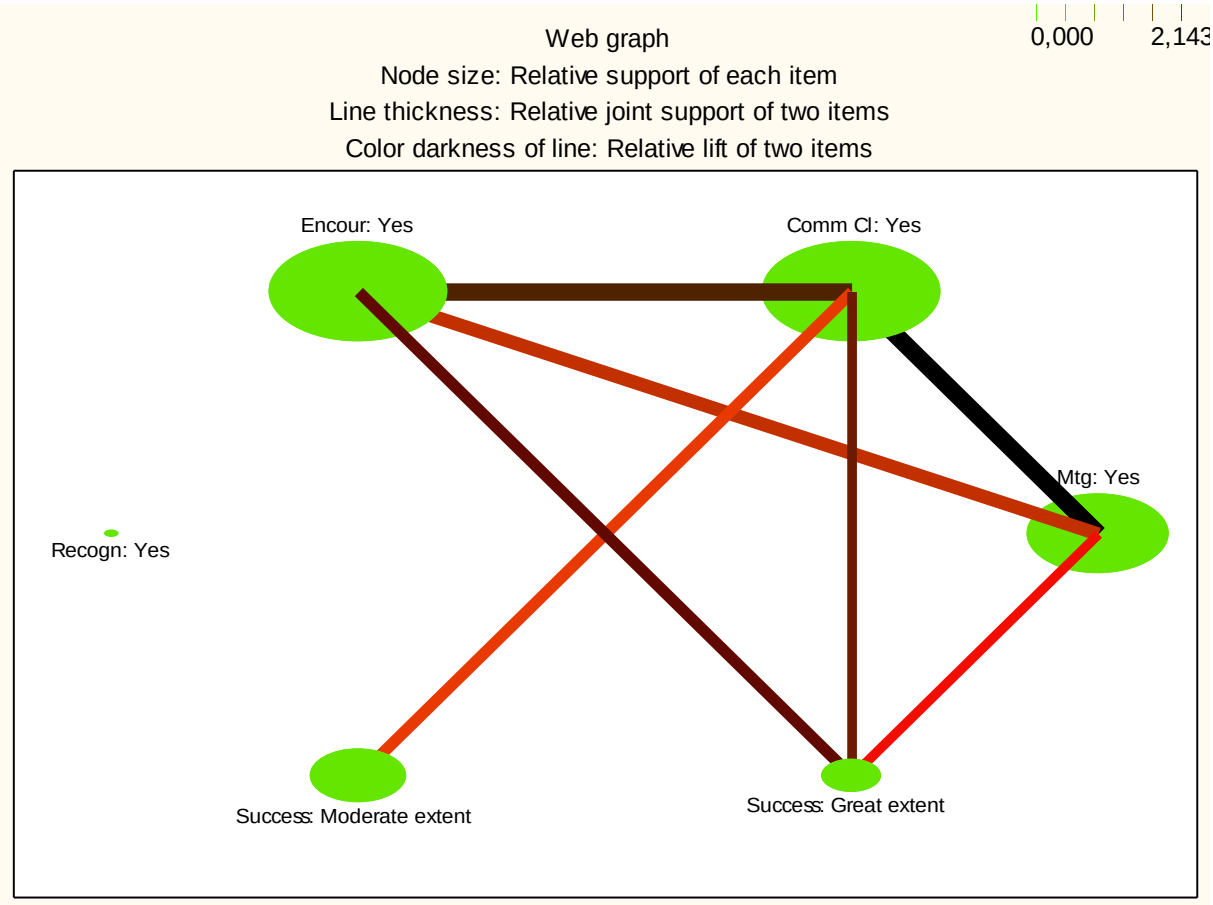

Figure 31: ARA results for staff encouragement methods and KM success. Min. support 0.15, confidence 0.15. Variables involved: Var. 28, Var. 44-47. Recogn: Com Cli Yes: Supporting a communicative work-climate; Mtg Yes: Regular meetings for knowledge exchange; Encour Yes: Encouraging employees to present knowledge/ideas; Recogn Yes: Recognition for sharing knowledge; Success: To what extent is this approach successful?

4.1.12.2 Association with own willingness to share

SAL showed that a great and a very great willingness to share knowledge can be associated with a communicative work climate, regular meetings and active encouragement to share knowledge, see *Figure 32*. These are the three encouragement practices that could be associated with great KM success as well, see *Figure 31*. As the increased willingness to share knowledge and a great KM success can be both associated with the same encouragement practices, it is likely that there is an association between the two as well.

Implications for practitioners are that in order to achieve a high willingness of staff to share their knowledge, they should support a communicative work-climate, set up regular meetings and actively encourage employees to share knowledge.

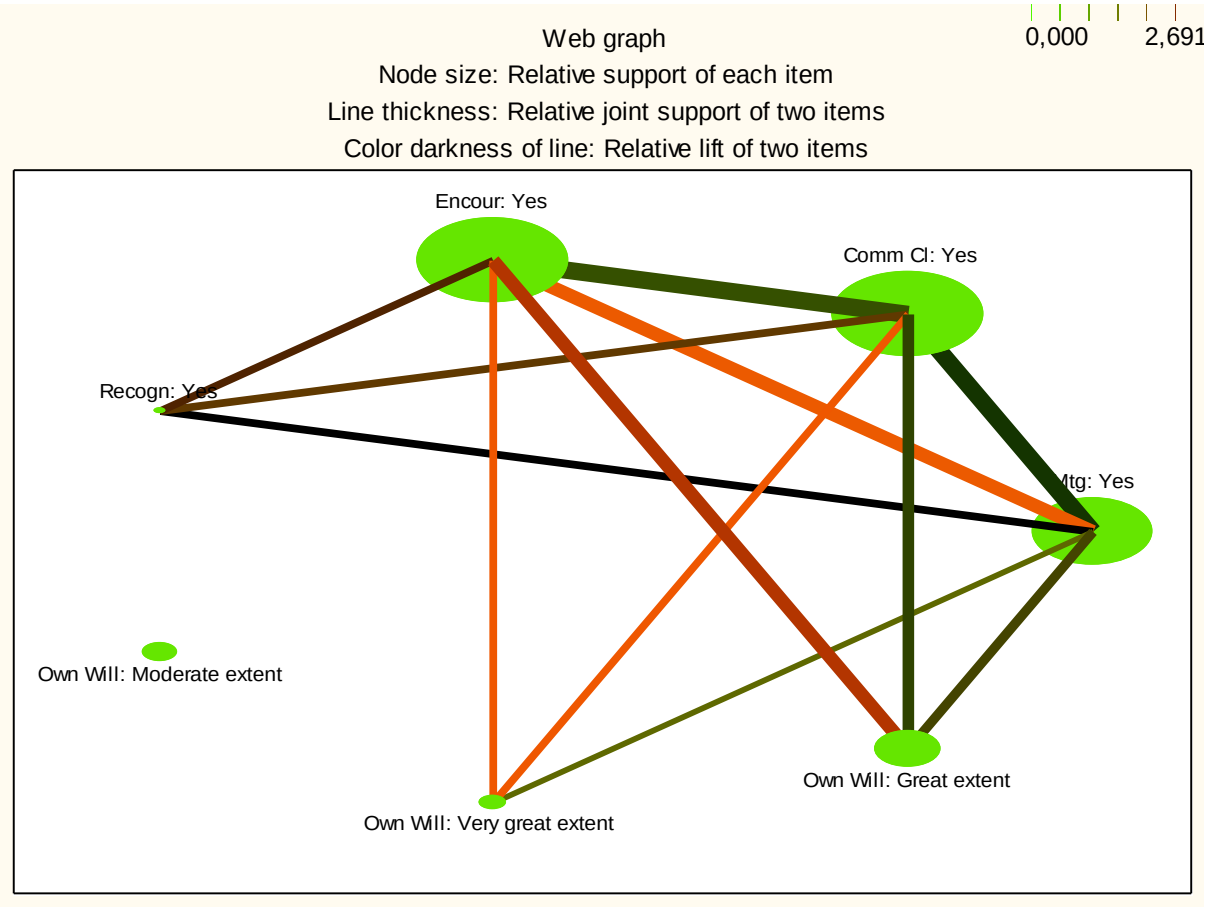

Figure 32: SAL results for own willingness to share knowledge and encouragement methods. Min. support 0.15, confidence 0.15. Variables involved: Var. 44-47, Var. 51. Recogn: Com Cli Yes: Supporting a communicative work-climate; Mtg Yes: Regular meetings for knowledge exchange; Encour Yes: Encouraging employees to present knowledge/ideas; Recogn Yes: Recognition for sharing knowledge; Own Will: How would you rate your willingness to share knowledge within the company?

4.1.13 *How would you rate your own willingness to share knowledge within the company?*

On the whole people showed a high willingness to share: most survey respondents rated their willingness to share their knowledge within their company as high (67% great to very great extent), see *Figure 33*. The results show that there are no significant differences between New Zealand and Germany. While New Zealanders were slightly more positive, ANOVA showed no statistically significant difference between New Zealanders and Germans regarding their willingness to share knowledge. See *Appendix C* for detailed survey analysis.

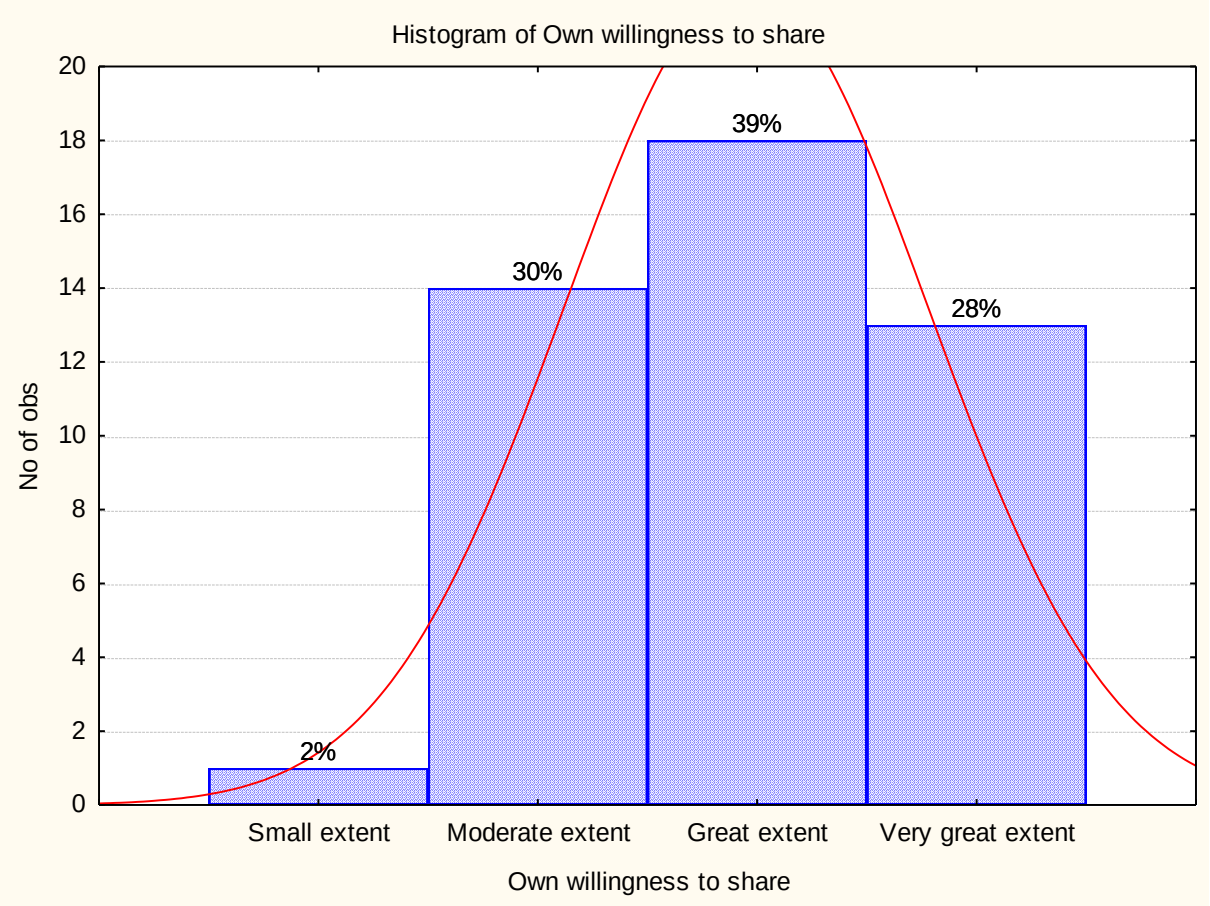

Figure 33: Perceived own willingness to share knowledge. Variables involved: Var. 51.

4.1.13.1 Association with organisational culture

The SAL showed that a great personal willingness to share is associated with an adequate to good organisational culture, see *Figure 34*. It is interesting that even an 'adequate' culture is sufficient for a 'great' willingness to share. What this suggests is that there may be thresholds for sharing. This was further explored by using a box plot (assuming a numerical ordered scale to the variable for willingness to share), see *Figure 35*.

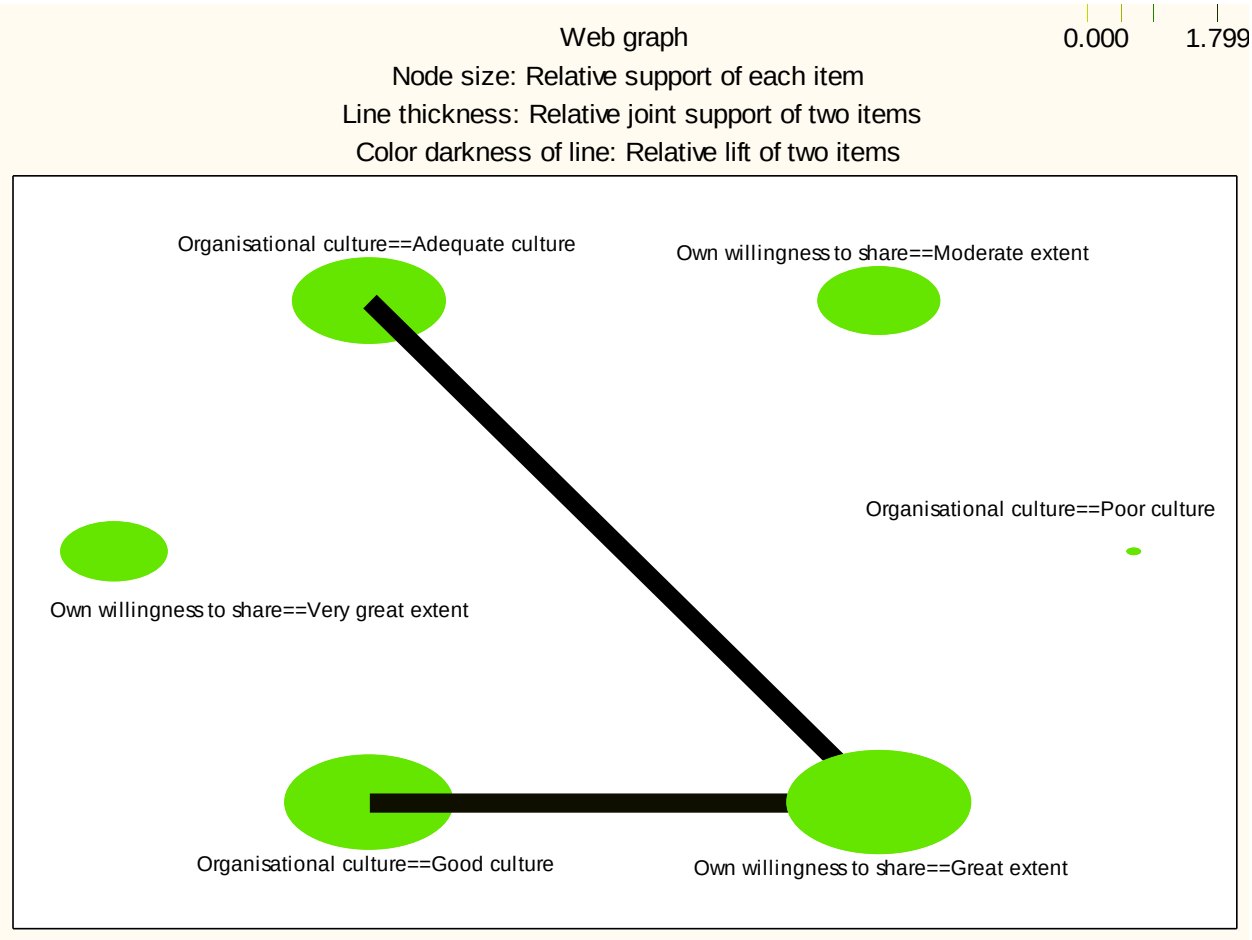

Figure 34: SAL for own willingness to share knowledge and organisational culture, min support 0.1, confidence 0.1. Variables involved: Var. 51, Var. 88.

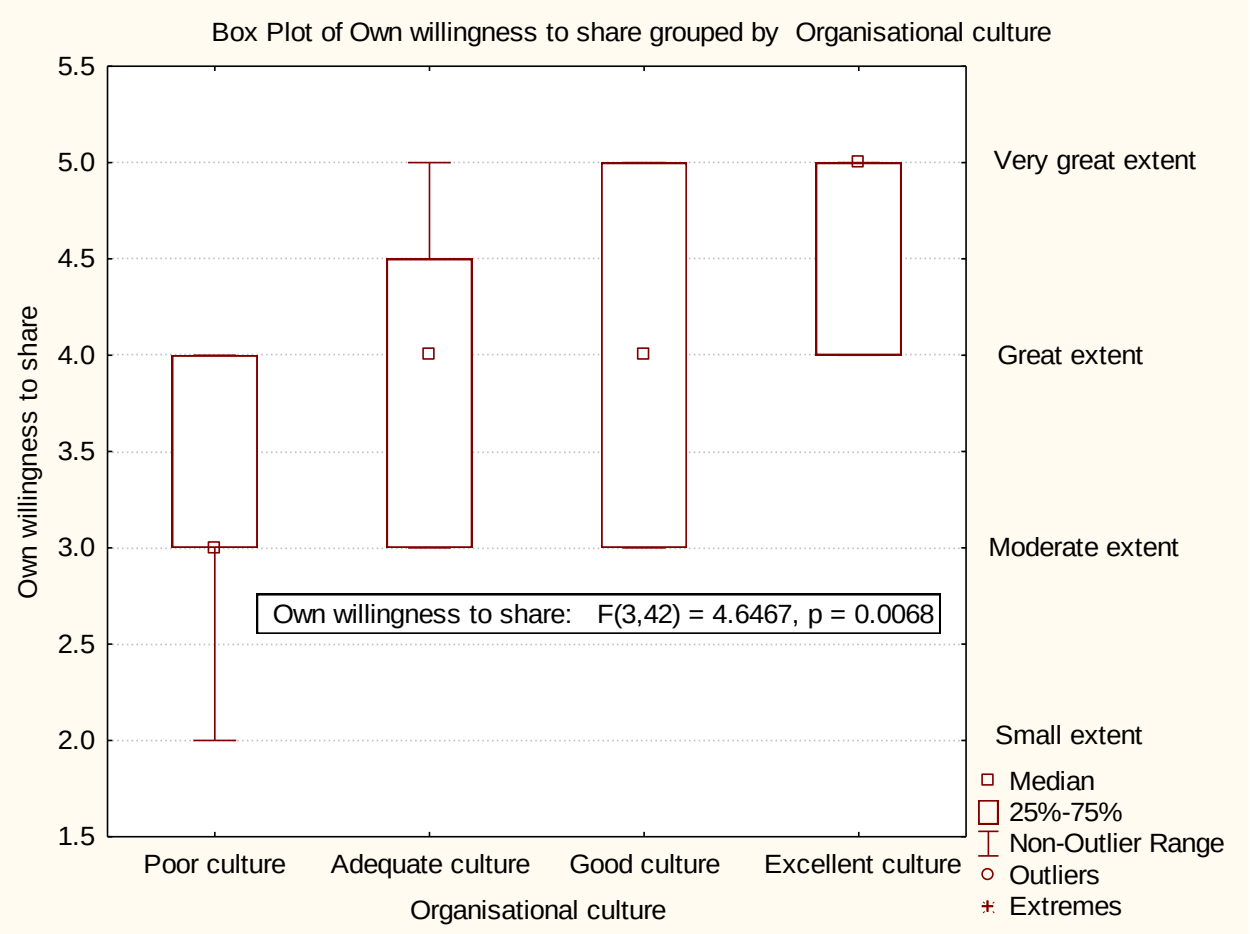

Figure 35: Box plot for willingness to share plotted and organisational culture. Variables involved: Var. 51, Var. 88.

The results showed that there is indeed a relationship. The ANOVA test showed that there is a significant difference (p=0.0068) in willingness to share across different organisational cultures. The relationship is one of increasing willingness to share with improved organisational culture. The effect is approximately linear, or at least monotonically upwards. It is interesting to note that even in poor cultures the willingness to share is still there to some extent.

However, for practitioners this suggests that a good work-climate will be beneficial for the knowledge sharing willingness of employees. The result could be a greater KM success.

4.1.14 WHAT FACTORS MAKE IT DIFFICULT FOR YOU TO SHARE YOUR KNOWLEDGE?

By far the most important difficulty regarding knowledge sharing is a lack of time, see *Figure 36.* According to the survey respondents, other factors that could have been expected more important (e.g. workgroup competition or a poor work-climate) did not have a big impact. No difference between respondents form New Zealand and Germany could be found. See *Appendix C* for detailed survey analysis.

The implications for practitioners are that sharing knowledge needs to be given a higher priority so people have more time to share. Also employees have to be aware of the benefits of doing so and try to take time to share knowledge. The other factors seem not as influential.

Figure 36: Factors that make it difficult for staff to share their knowledge. Variables involved: Var. 52-63.

4.1.15 *How would you rate your willingness to ask questions in order to acquire knowledge?*

Most respondents (85%) found that they had a great or very great willingness to ask questions in order to acquire knowledge. 13% stated that they were moderately willing to ask, and only 2% found that they were only willing to ask to a small extent, see *Figure 37*.

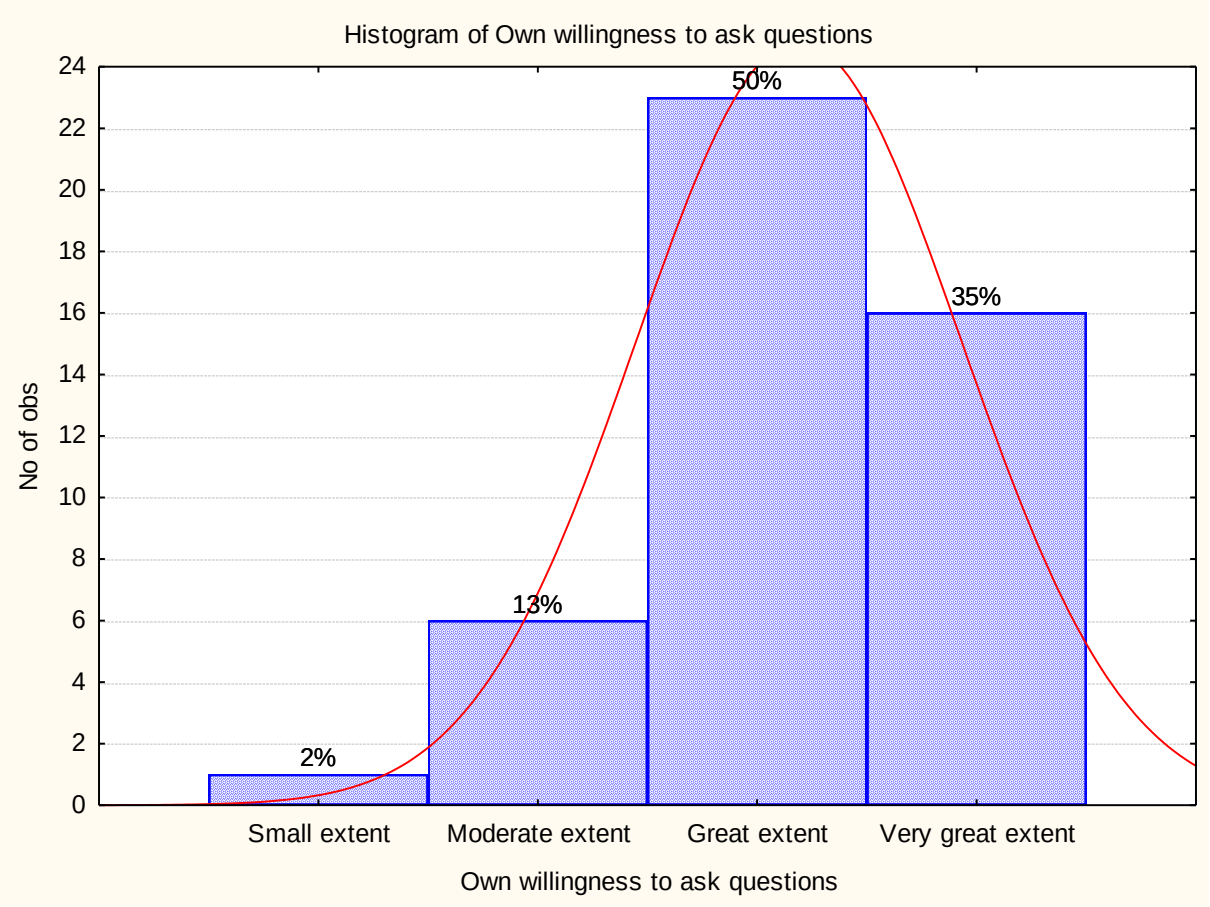

Figure 37: Perceived own willingness to ask questions in order to acquire knowledge. Variables involved: Var. 65.

On the whole respondents in New Zealand answered more positive regarding their willingness to ask questions to acquire knowledge than respondents in Germany, see *Figure 38*. The ANOVA result (p=0.01) showed that the difference is statistically significant, see *Figure 39*.

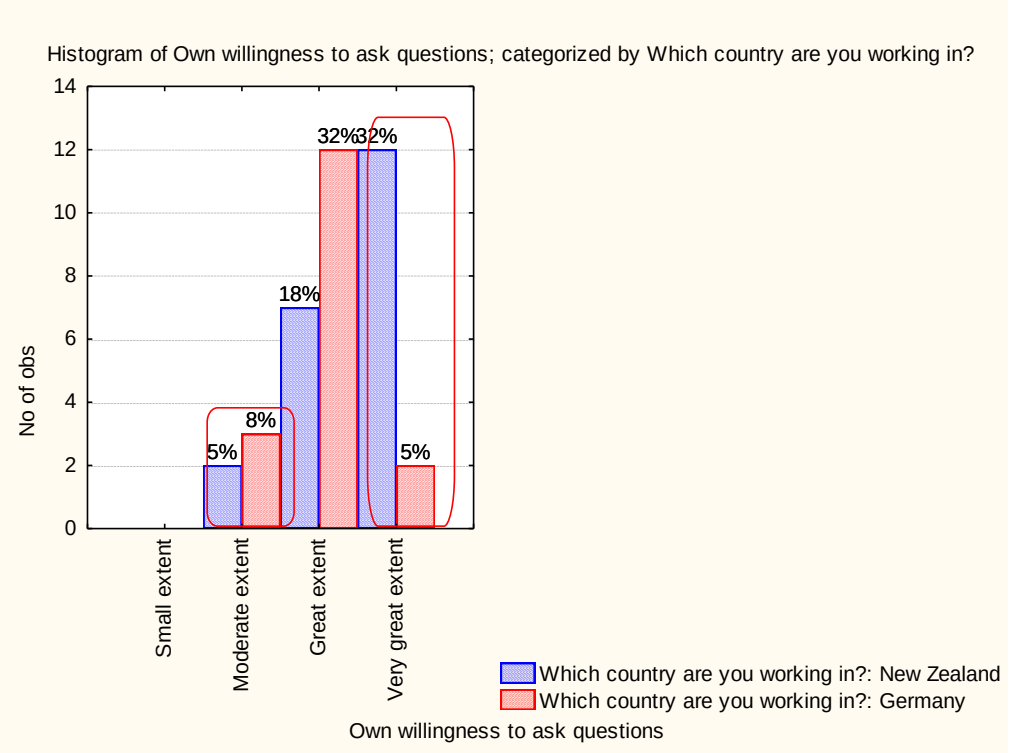

Figure 38: Difference between New Zealand and Germany regarding the willingness to ask questions.

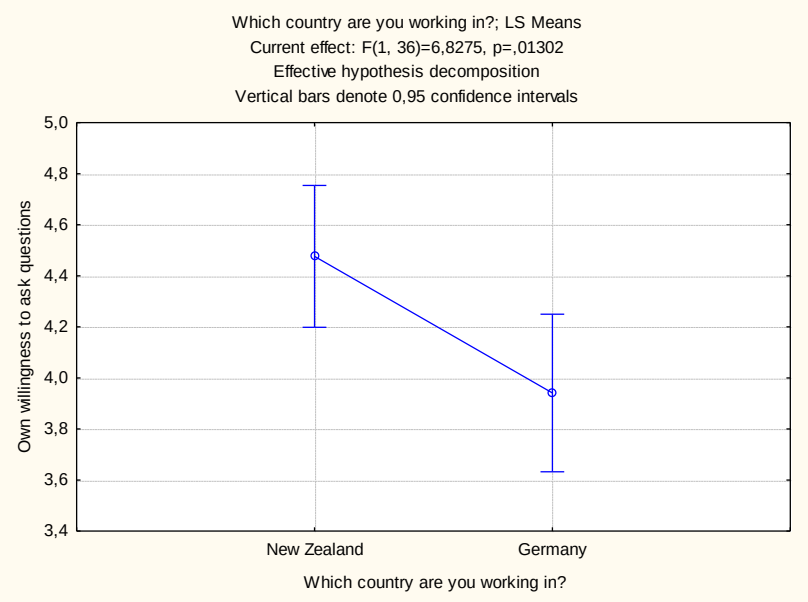

Figure 39: ANOVA results for the difference between New Zealand and Germany regarding the willingness to ask questions.

4.1.15.1 Association with organisational culture

When examining the variables of organisational culture (work-climate) and willingness to ask questions, the SAL showed that an adequate culture is associated with a great willingness, and a good culture with a very great willingness, see *Figure 40*.

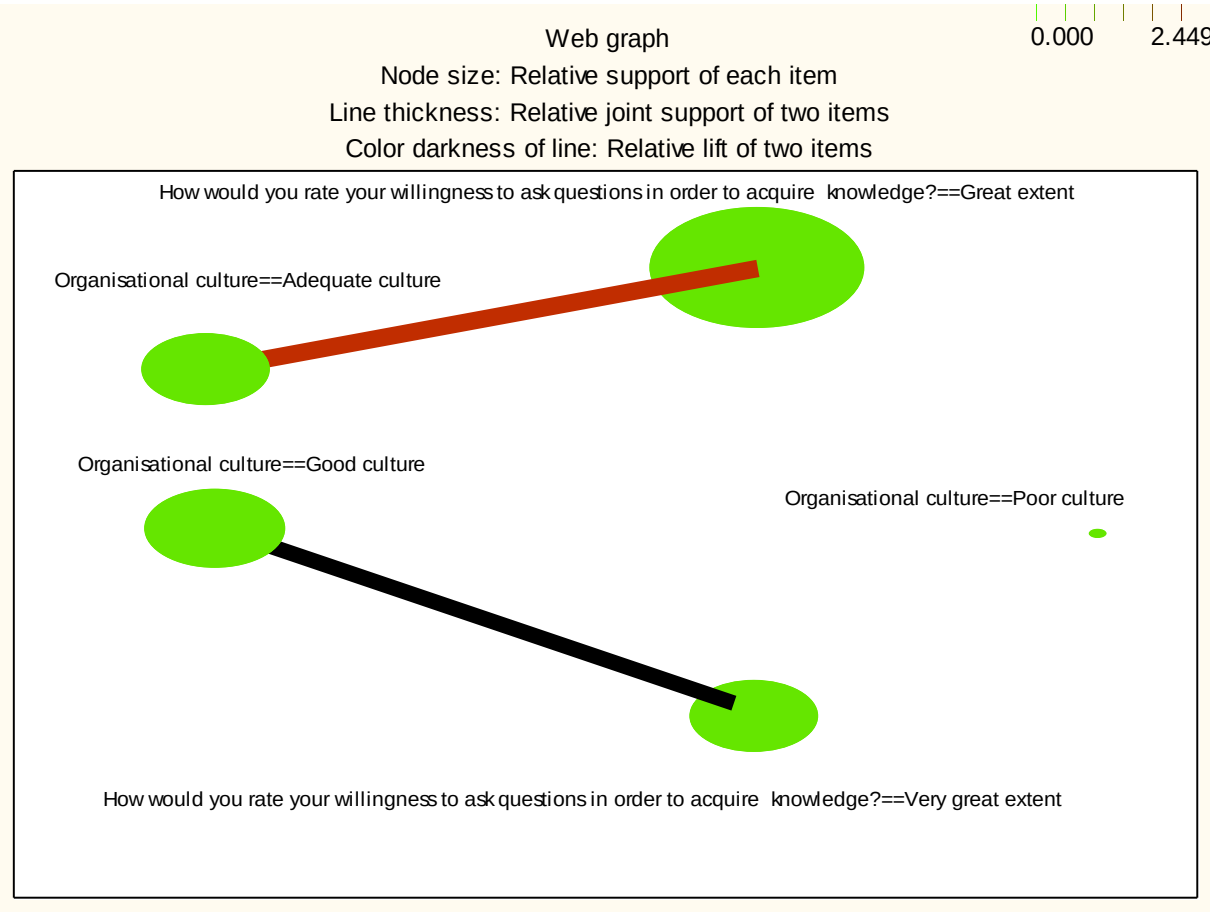

Figure 40: SAL results for willingness to ask and organisational culture. Min. support 0.1, confidence 0.1. Variables involved: Var. 65, Var. 88.

Although the SAL found an association between specific answers in the two variables, there is no relationship overall, as *Figure 41* shows.

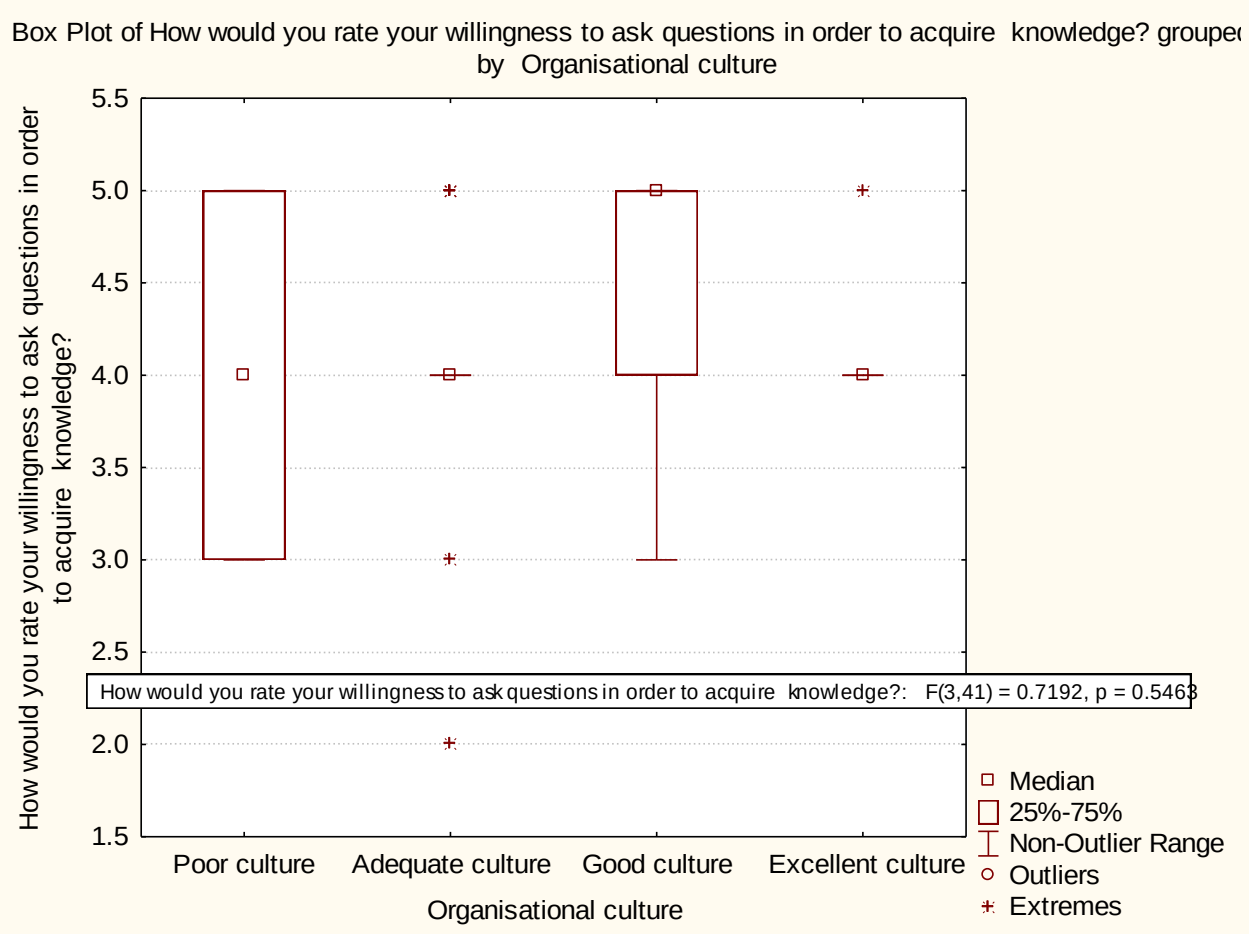

Figure 41: Box plot for willingness to ask questions and organisational culture. Variables involved: Var. 65, Var. 88.

Although there is an upward trend (see *Figure 41*), the results are not statistically significant (p=0.546). So we conclude from this that willingness to ask questions is not necessarily associated with the work-climate. A bigger survey is required to examine the relationship between organisational culture and the willingness to ask question.

4.1.15.2 Association with the own willingness to share knowledge

SAL showed that a great willingness to ask questions can be associated with a great and a moderate willingness to share own knowledge, see *Figure 42*. It is interesting to see that people with only a moderate willingness to share their own knowledge can still be associated with a great willingness to ask questions to acquire knowledge. Personal goals and ambition could be a reason for that. While people do not want to share the knowledge they posses, they still like to acquire new knowledge from others in order to for example strengthen their position in the company. Also an association between a very great willingness to ask questions and a very great willingness to share own knowledge could be found. This could be the result of noble reasons, like helping and supporting colleagues or of a high awareness of the benefit of these knowledge sharing processes to the company.

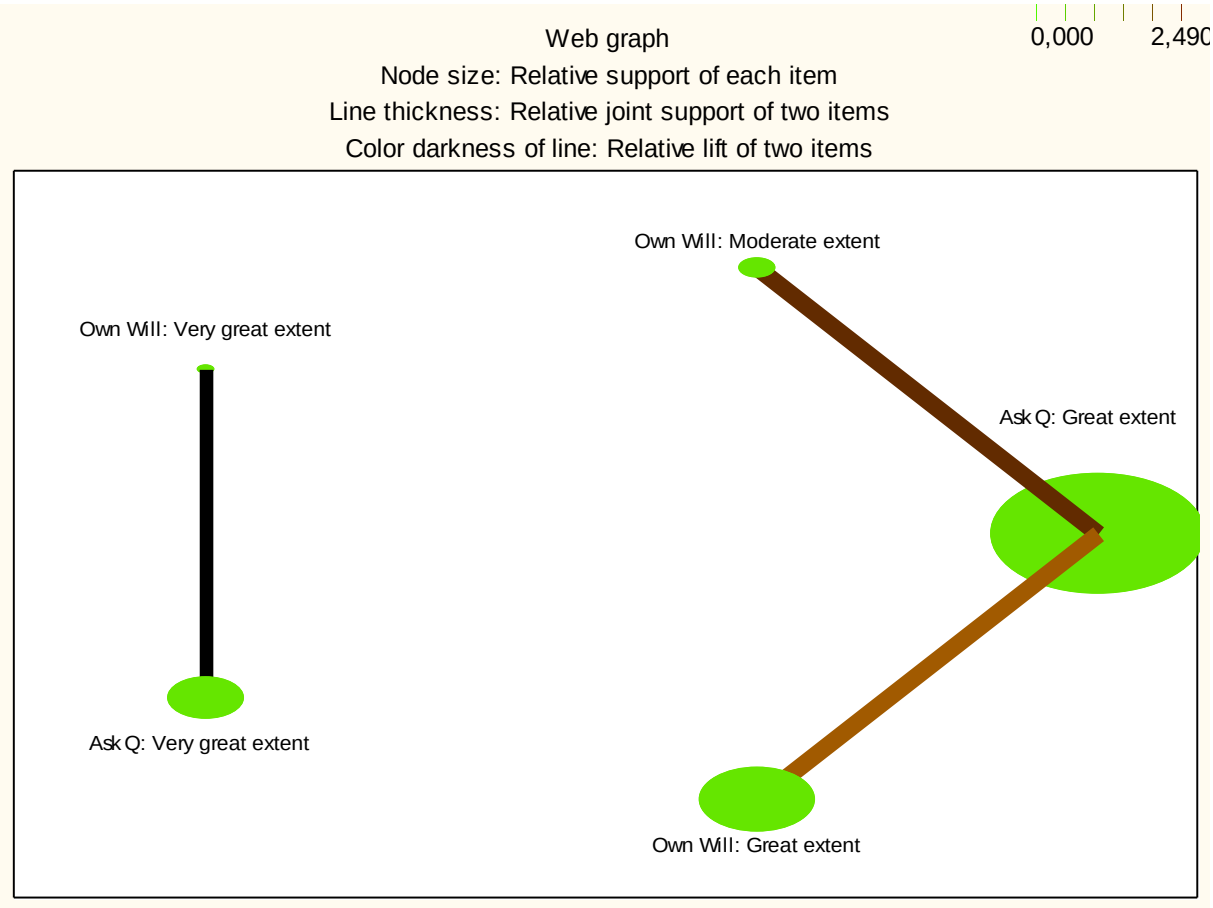

Figure 42: SAL for willingness to ask vs. own willingness to share. Min support 0.1, confidence 0.1. Variables involved: Var. 65, Var. 51. Recogn: Own Will: How would you rate your willingness to share knowledge within the company?; Ask Q: How would you rate your willingness to ask questions in order to acquire knowledge?

4.1.15.3 Association with the willingness of co-workers to share knowledge

A great willingness to ask questions to acquire knowledge can be associated with a great willingness of co-workers to share their knowledge. However, an association with a moderate willingness of co-workers to share and a great own willingness to ask questions could still be found, see *Figure 43*. This could mean that employees have a great willingness to ask for knowledge even if their colleagues are only moderately willing to share. It is possible that the attitude regarding sharing knowledge does not have a big influence on the willingness of staff to ask questions.

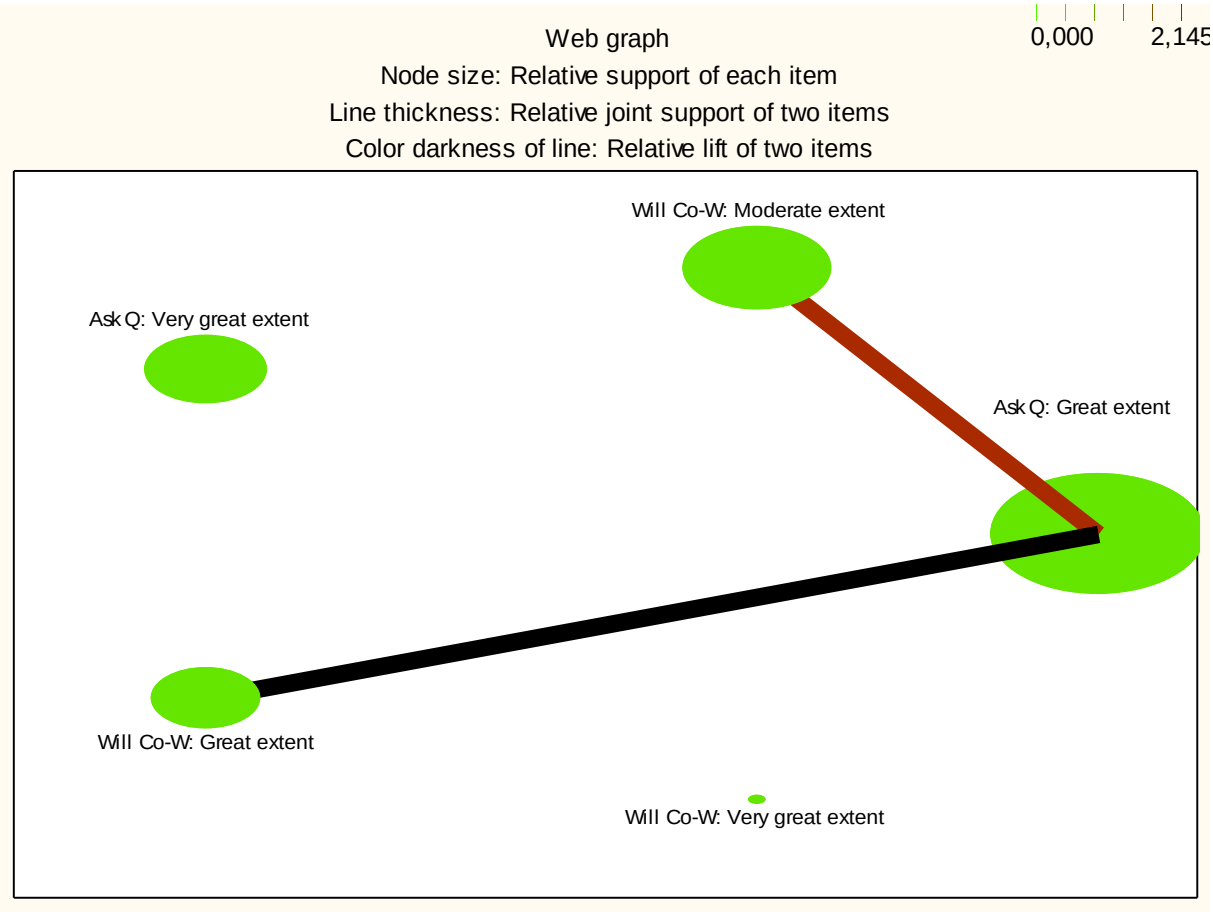

Figure 43: SAL for willing to ask vs. willingness of co-workers to share. Min support 0.1, confidence 0.1. Variables involved: Var. 65, Var.66. Recogn: Ask Q: How would you rate your willingness to ask questions in order to acquire knowledge?; Will Co-W: How would you rate the willingness of your co-workers to share knowledge within the company?

4.1.15.4 Association with own openness

Results showed, expectedly, that people with great openness also had a great willingness to ask questions. But even a moderate openness can be associated with a great willingness to ask questions, see *Figure 44*. Maybe a moderate openness is sufficient to be willing to ask questions. The reasons to do so can vary. While people might sometimes ask questions, because they simply are interested, there might be situations when they are forced to acquire knowledge from others to successfully complete their job. In this case openness would possible not be very relevant.

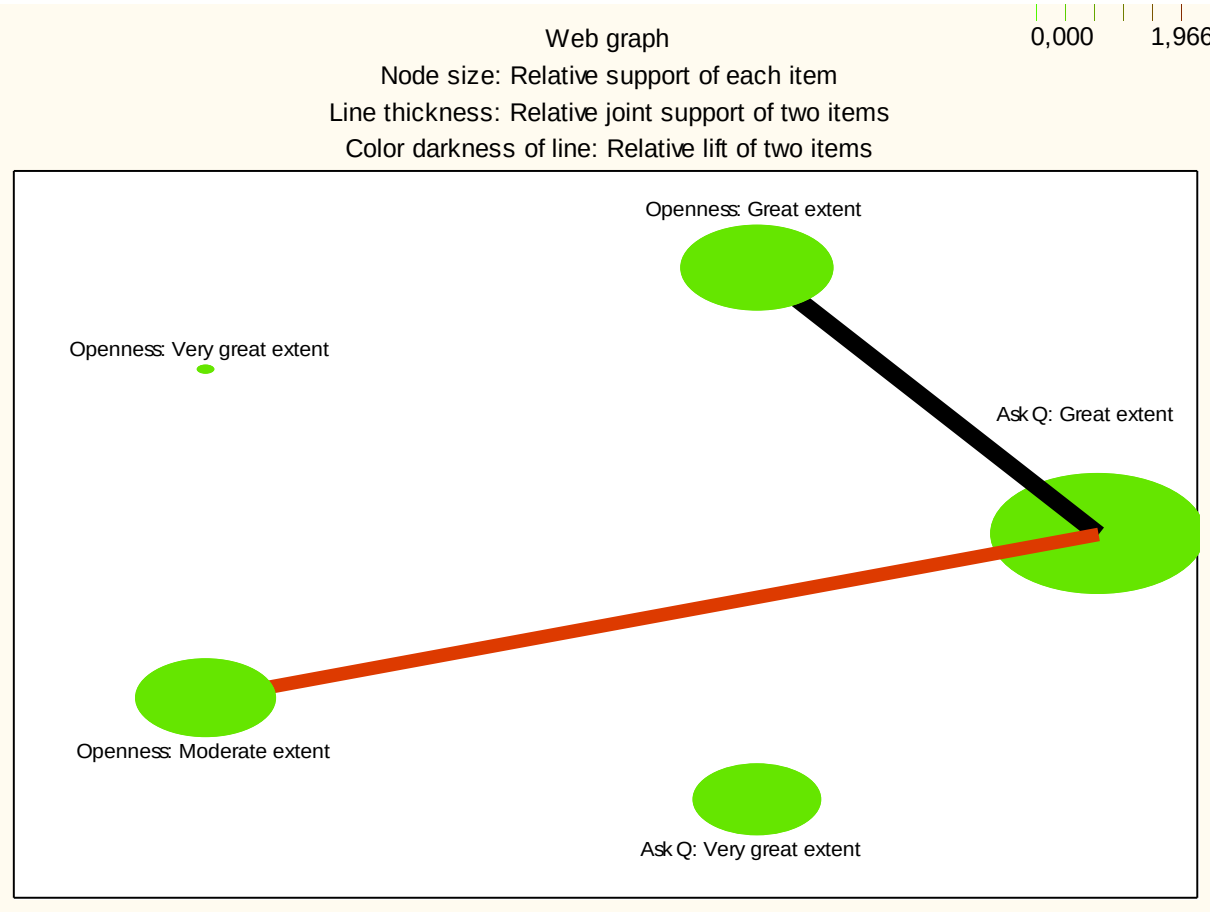

Figure 44: SAL for willingness to ask and openness. Min support 0.1, confidence 0.1. Variables involved: Var. 65, Var. 83. Recogn: Ask Q: How would you rate your willingness to ask questions in order to acquire knowledge?; Openness: To what extent do you consider yourself an 'open' person?

4.1.15.5 Association with own extraversion

A great willingness to ask questions was associated with a moderate degree of extraversion. Also there is an association between a moderate degree of extraversion and a very great willingness to ask questions, see *Figure 45*. It is surprising that no association between a great extraversion and a great willingness to ask questions could be found. It is possible that a survey with a higher number of participants would be required to further research this result.

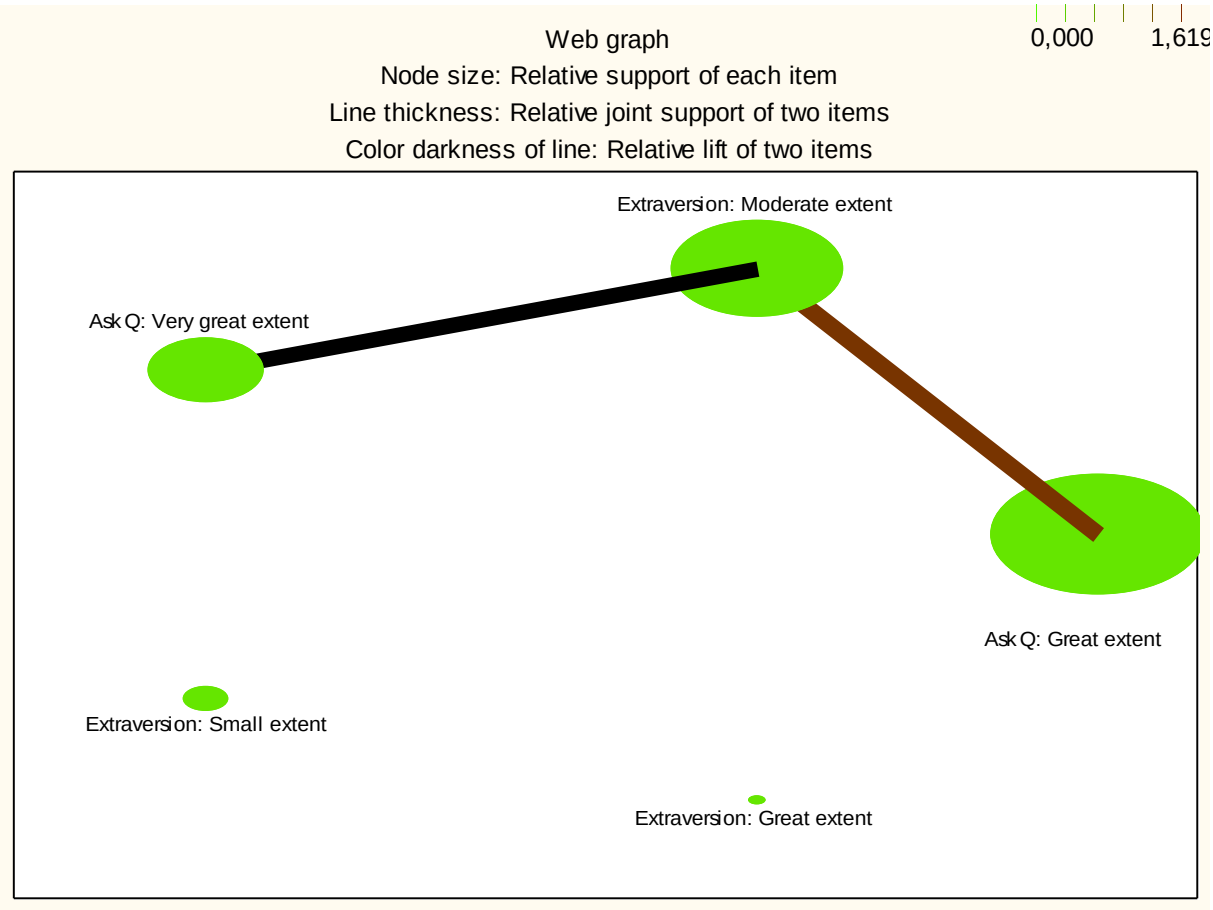

Figure 45: SAL for willingness to ask and extraversion. Min support 0.1, confidence 0.1. Variables involved: Var. 65, Var. 82. Recogn: Ask Q: How would you rate your willingness to ask questions in order to acquire knowledge?; Extraversion: To what extent do you consider yourself an extraverted person?

4.1.16 *How would you rate the willingness of your co-workers to share knowledge within the company?*

Most survey respondents (41%) found that their co-workers were willing to share their knowledge to a moderate extent. However, more than half of the respondents rated the willingness of their co-workers to share their knowledge as high (52% great to very great extent), *see Figure 46*.

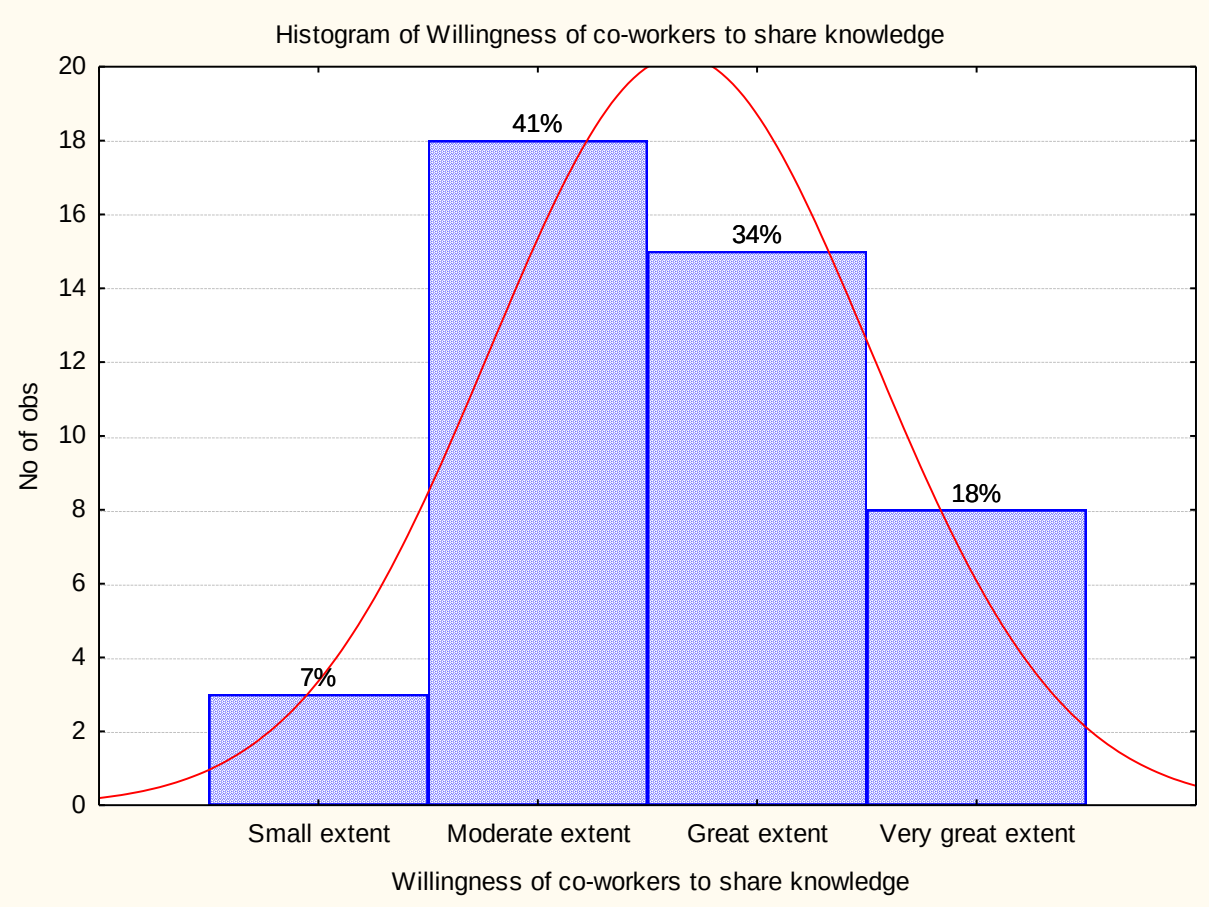

Figure 46: Perceived willingness of co-workers to share knowledge. Variables involved: Var. 66.

New Zealanders tended to be slightly more positive regarding the willingness of co-workers to share knowledge than Germans. But ANOVA showed that these results are not statistically significant (ANOVA p=0.45). See *Appendix C* for detailed survey analysis.

SAL showed no association between the willingness of co-workers to share information and the organisational culture (work-climate). Nonetheless there is an overall trend, as the box plot of *Figure 47* shows. People perceived that their co-workers were more willing to share knowledge in better organisational culture. Perhaps this is a natural and defining characteristic of organisational culture in the first place.

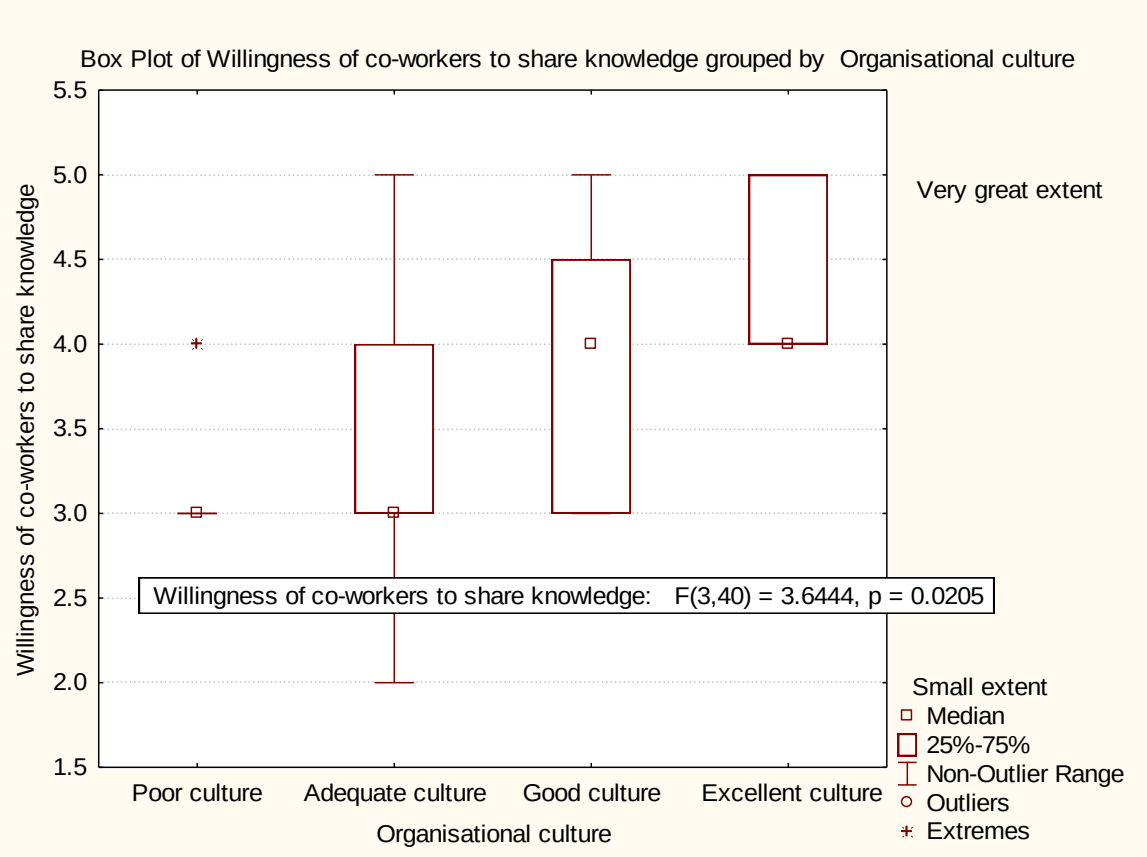

Figure 47: Box plot for willingness of co-workers to share knowledge and organisational culture. Variables involved: Var. 66, Var. 88.

4.1.17 WHAT WOULD KEEP YOU FROM SEEKING KNOWLEDGE FROM OTHERS?

As shown in *Figure 48*, the biggest reason not to seek knowledge from others is a poor relationship with them. Other important factors were that people found that they had no motivation or reason to do so and that they did not need their knowledge. New Zealanders seemed to have a stronger tendency than Germans to think that there was no reason to seek knowledge from colleagues. But according to ANOVA there is no statistically significant difference. See *Appendix C* for detailed survey analysis.

The implications for practitioners are that if they base their knowledge sharing on personal interactions between employees rather than on technology (e.g. databases), they will have to be aware of the relationships of their staff. Also a strong emphasis has to be put on recruiting people to make sure they fit in the organization and the project team.

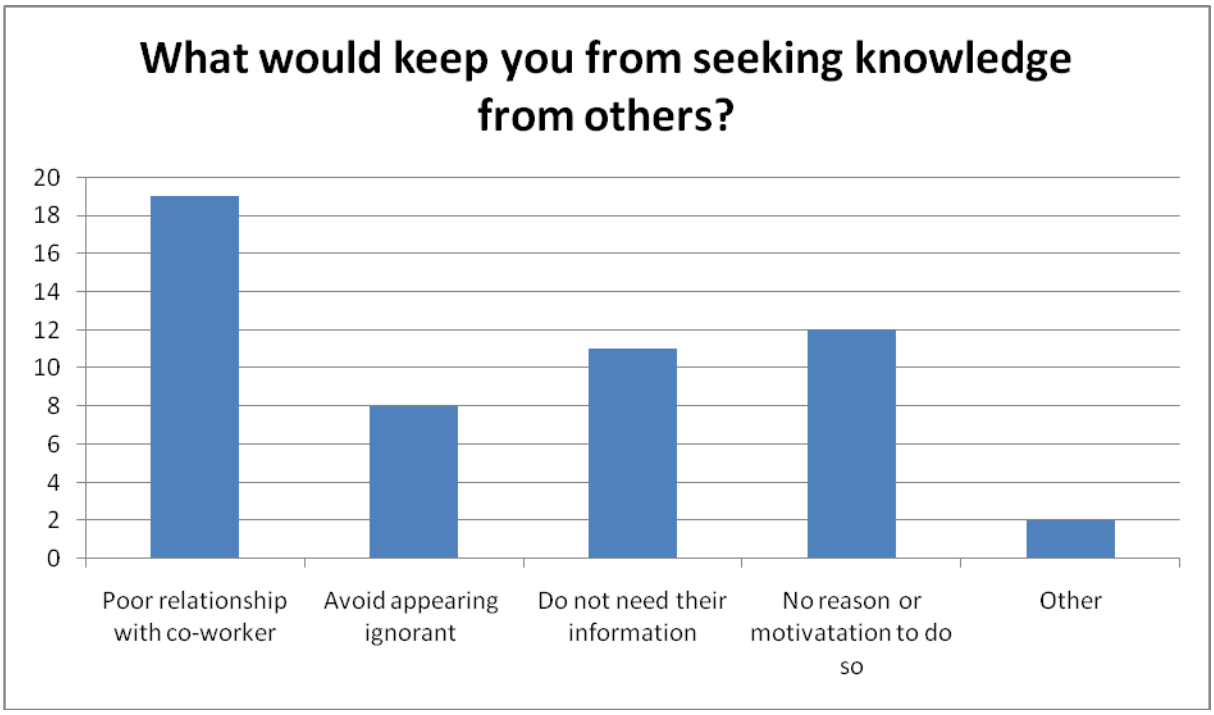

Figure 48: Reasons not to seek knowledge from others. Variables involved: Var. 67-73.

4.1.18 To what extent would you consider yourself an extraverted person?

Most respondents (43%) considered themselves moderately extraverted, see *Figure 49*. The tendency is rather negative. Germans rated themselves more extraverted than New Zealanders (18% compared to 3% for great extent of extraversion), see *Figure 50*. This difference was proven statistically significant through ANOVA (p=0.01), see *Figure 51*.

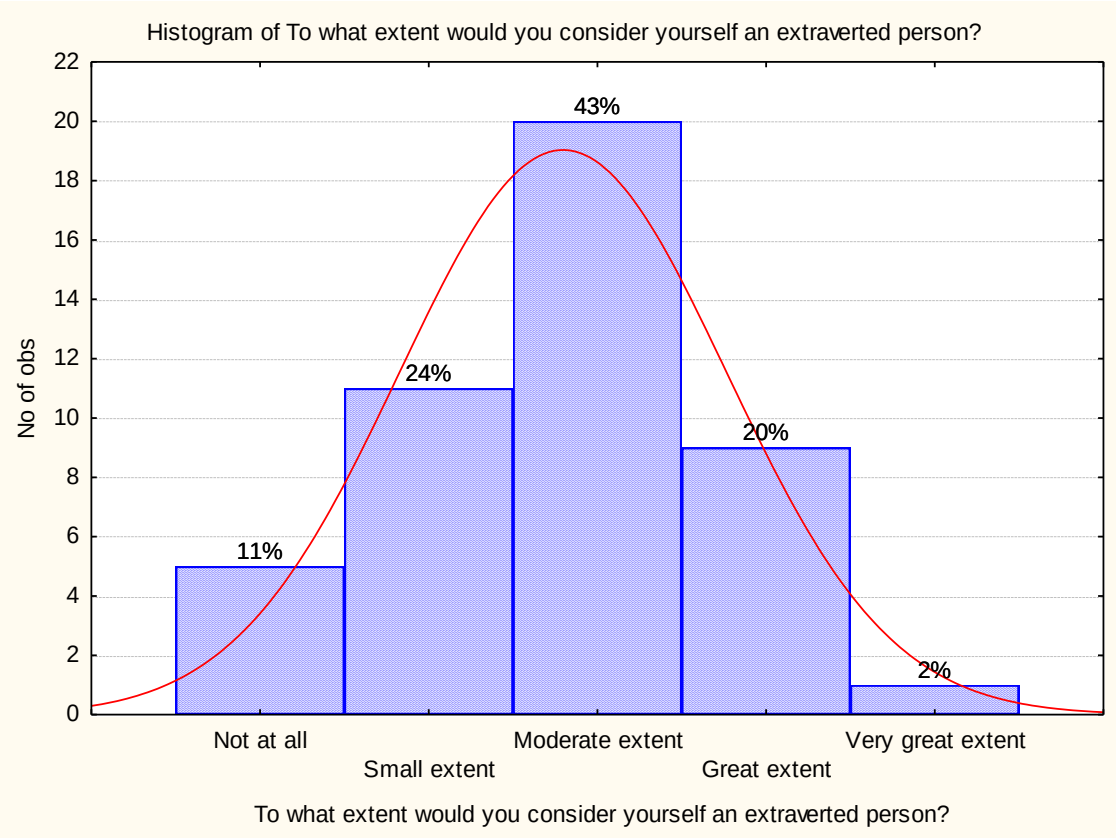

Figure 49: Perceived extraversion of survey respondents. Variables involved: Var. 82.

This result is interesting, as New Zealanders rate their willingness to ask questions more positive than Germans. One could have expected that people who rate themselves more extraverted would have a higher willingness to ask questions. The result may reflect personal confidence or maybe general cultural differences as to asking questions.

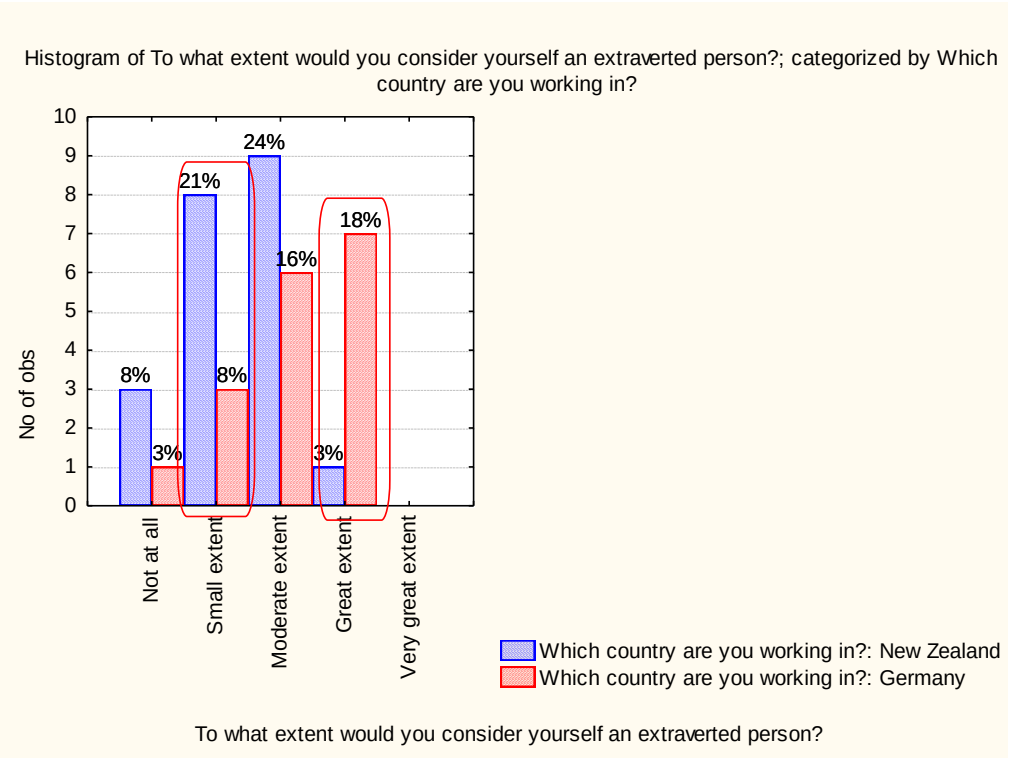

Figure 50: Difference of perceived extraversion between New Zealanders and Germans.

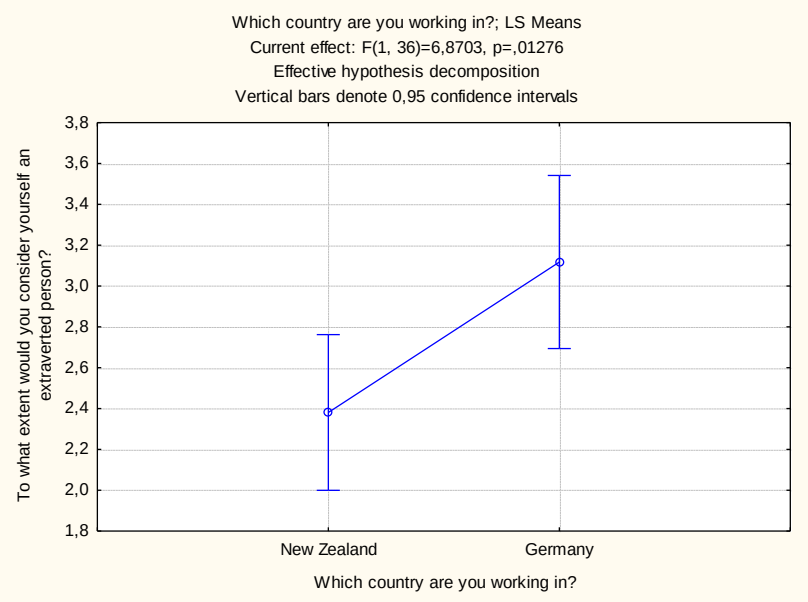

Figure 51: ANOVA result for the difference regarding extraversion between New Zealanders and Germans.

4.1.19 TO WHAT EXTENT DO HR MANAGEMENT INCENTIVES SUPPRESS KNOWLEDGE SHARING?

The results in *Figure 52* show that HR incentives can have some effects as a disincentive to sharing knowledge within firms. 33% of the survey participants found that HR incentives suppress knowledge sharing to a moderate extent, and 11% rated the effect as a disincentive to sharing knowledge as great or even very great. But no significant differences between New Zealand and Germany were found. See *Appendix C* for detailed survey analysis.

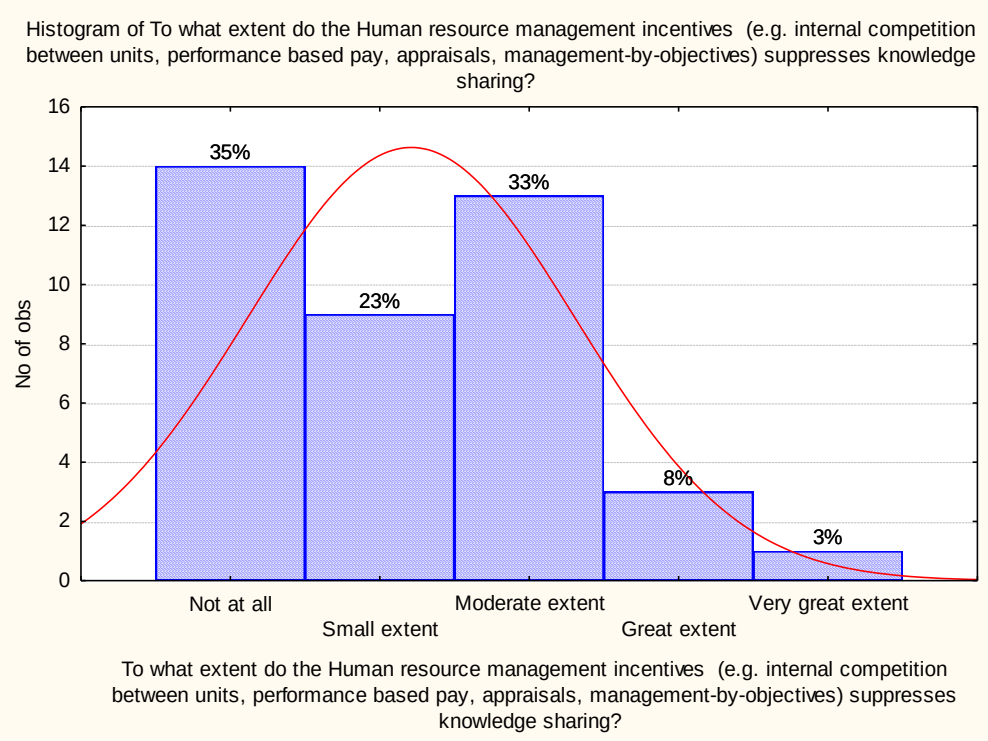

Figure 52: Negative influence of HR incentives on knowledge sharing. Variables involved: Var. 84.

4.1.20 *Where there is a willingness to share knowledge, is it stronger within a workgroup than in the wider organisation?*

Figure 53 shows that on the whole the willingness to share knowledge is greater in workgroups than in the wider organisation (74% said 'cautiously yes' to 'definitely yes'). There is no significant difference between New Zealand and Germany. See *Appendix C* for detailed survey analysis.

Implications for practitioners are that workgroups might need to be encouraged to share their acquired knowledge more within the organisation. The sharing process within the workgroup itself seems to work well; at least the willingness to share knowledge is higher. Practitioners could, for example, encourage members of the group to present new findings during regular meetings or to create presentations for the company's database. This could happen when a milestone of the NPD project is reached.

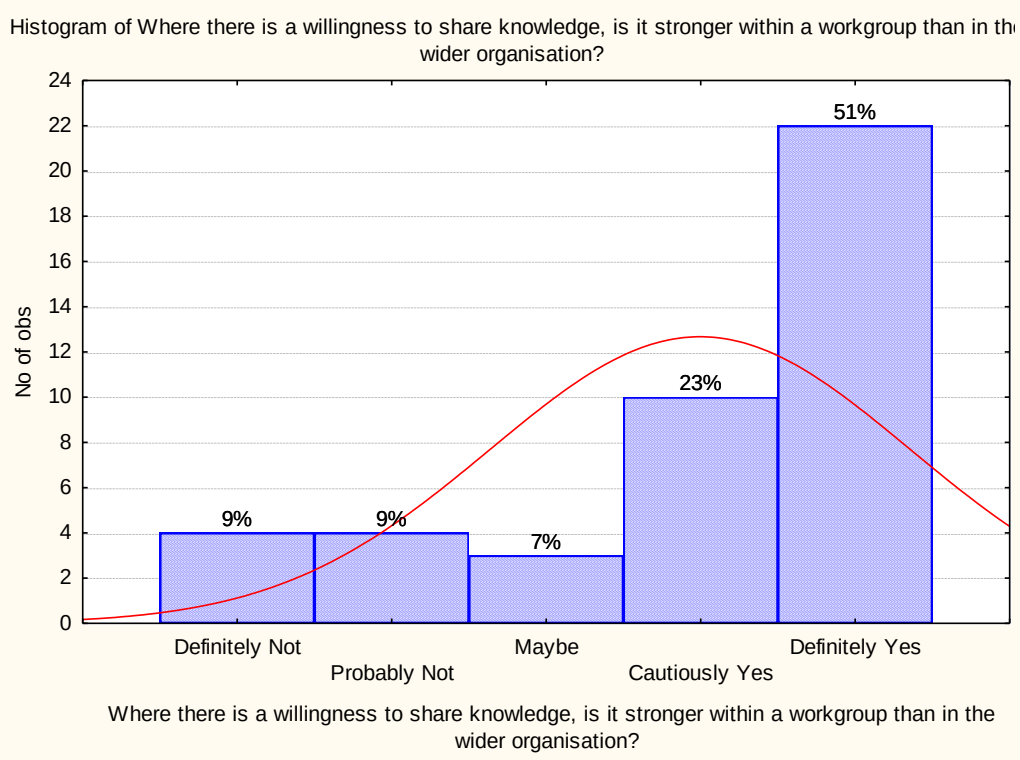

Figure 53: Results for: Is the willingness to share knowledge stronger in workgroups than in the wider organisation? Variables involved: Var. 85.

4.1.21 *To what extent does the kind of relationship you have to your co-workers influence your willingness to share knowledge or ask them to do so?*

The influence of personal relationships of co-workers has a rather significant impact on the knowledge transfer process between them, see *Figure 54*. 50% of the respondents found that the influence was great or very great, while 33% found it was moderate. Only 18% found that it had a small impact or none at all.

As personal relationships play such an important part for personal knowledge sharing mechanisms, it is essential for companies that put their emphasis on the personalization strategy to ensure a good work-climate and to be aware of potential problems between employees. Also it could be helpful to educate people about the importance of KM strategies for the company and about the benefits for themselves. Potentially this could decrease the influence of personal relationships, as the overall importance of these processes is understood better.

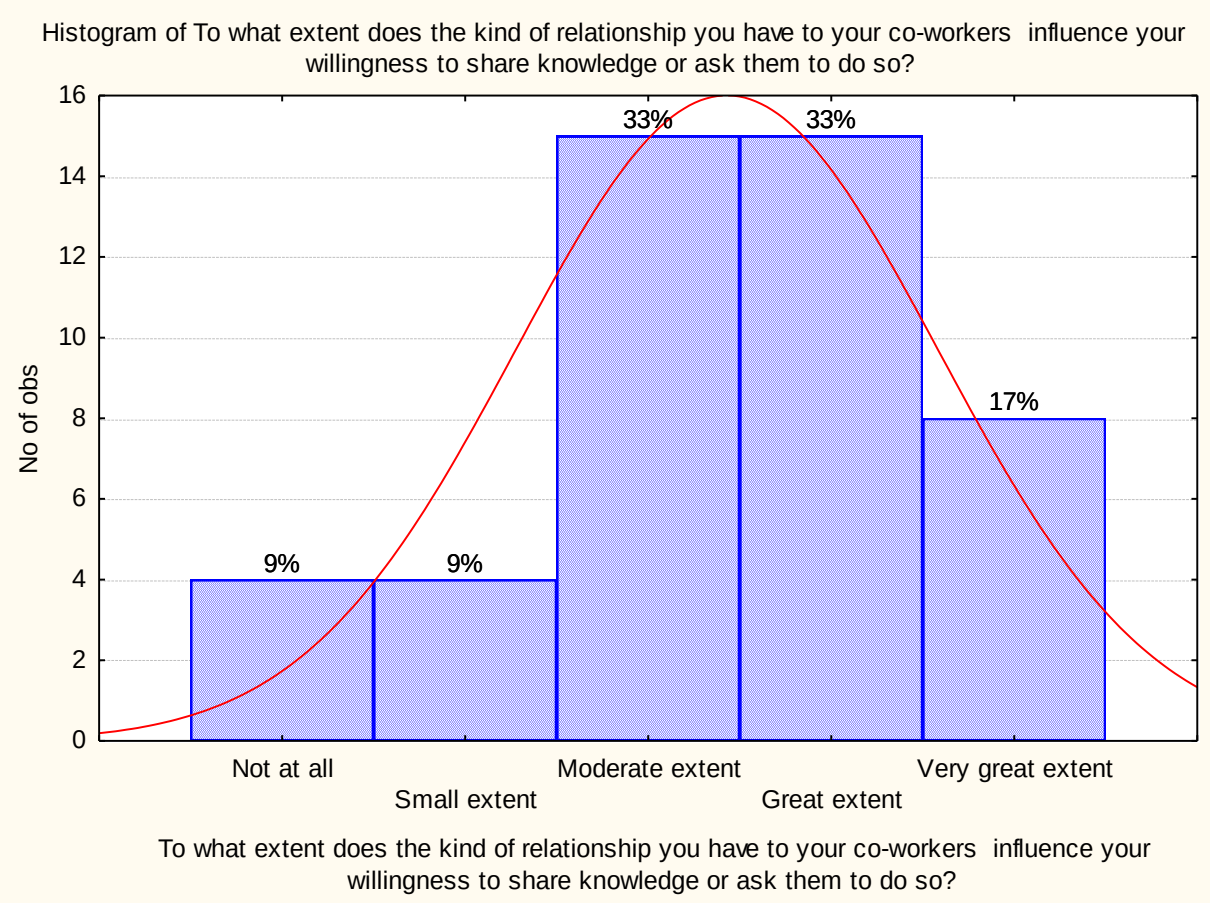

Figure 54: Influence of the kind of relationships with co-workers on the willingness to share and ask for knowledge. Variables involved: Var. 86.

The results show that the influence of personal relationships is even greater in German companies than in New Zealand. No German survey respondent found that the personal relationship to their co-workers had only a low influence, or none, see *Figure 55*.

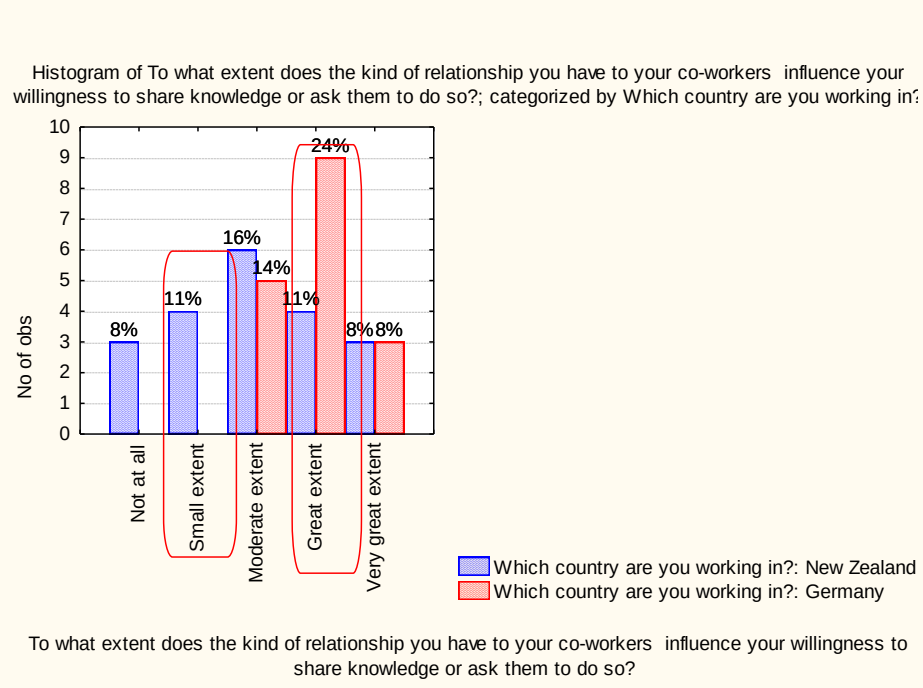

Figure 55: Difference between New Zealanders and Germans regarding the influence of personal relationships on knowledge sharing.

The difference is statistically significant (p=0.02), see ANOVA result *Figure 56*.

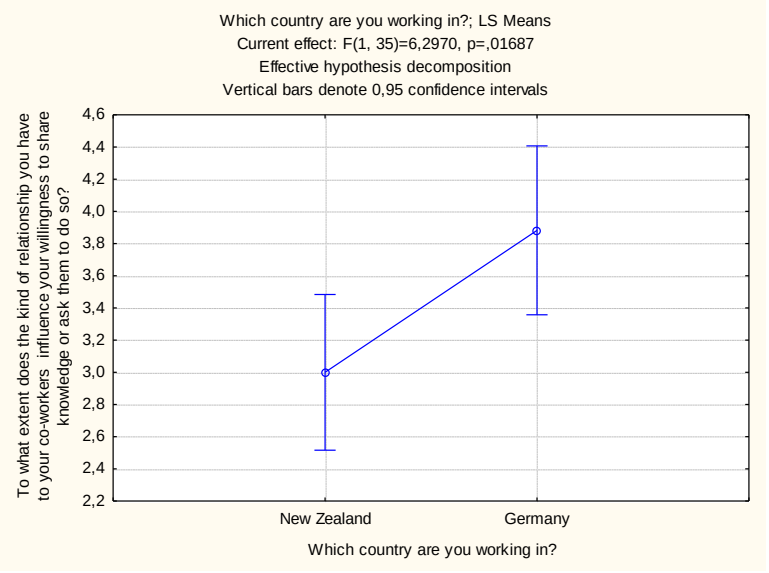

Figure 56: ANOVA result for the difference between New Zealanders and Germans regarding the influence of personal relationships on knowledge sharing.

4.1.22 *To what extent does trust influence your willingness to share and ask for knowledge?*

65% of the survey participants thought that trust has a great or very great influence on sharing and asking for knowledge. On the whole trust has a great influence on knowledge sharing processes in a company, see *Figure 57*.

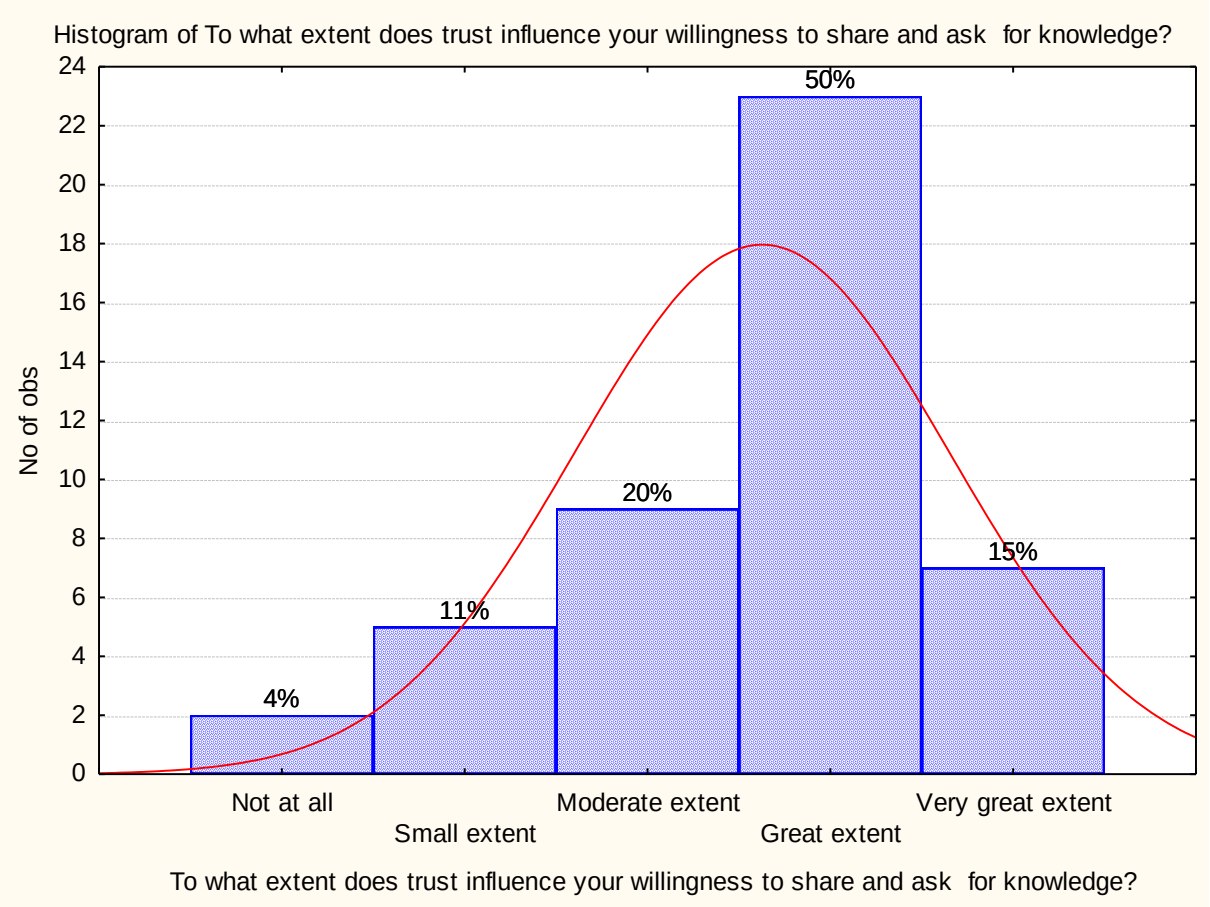

Figure 57: Influence of trust on the willingness to share and ask for knowledge. Variables involved: Var. 87.

People in Germany found that the influence of trust for knowledge sharing is higher than the New Zealanders, see *Figure 58*. ANOVA showed that this result is statistically significant (p=0.00), see *Figure 59*. Whether this is related to company size or a cultural effect is uncertain. New Zealanders seem more willing to take a risk. Maybe the society and work-climate in particular are less competitive in New Zealand than in Germany. Ethics within the company could play a role as well. Maybe Germans are more careful as to knowledge sharing, because they are more concerned that others might benefit from their knowledge, or that knowledge could be used against them in case it was incorrect or inadequate.

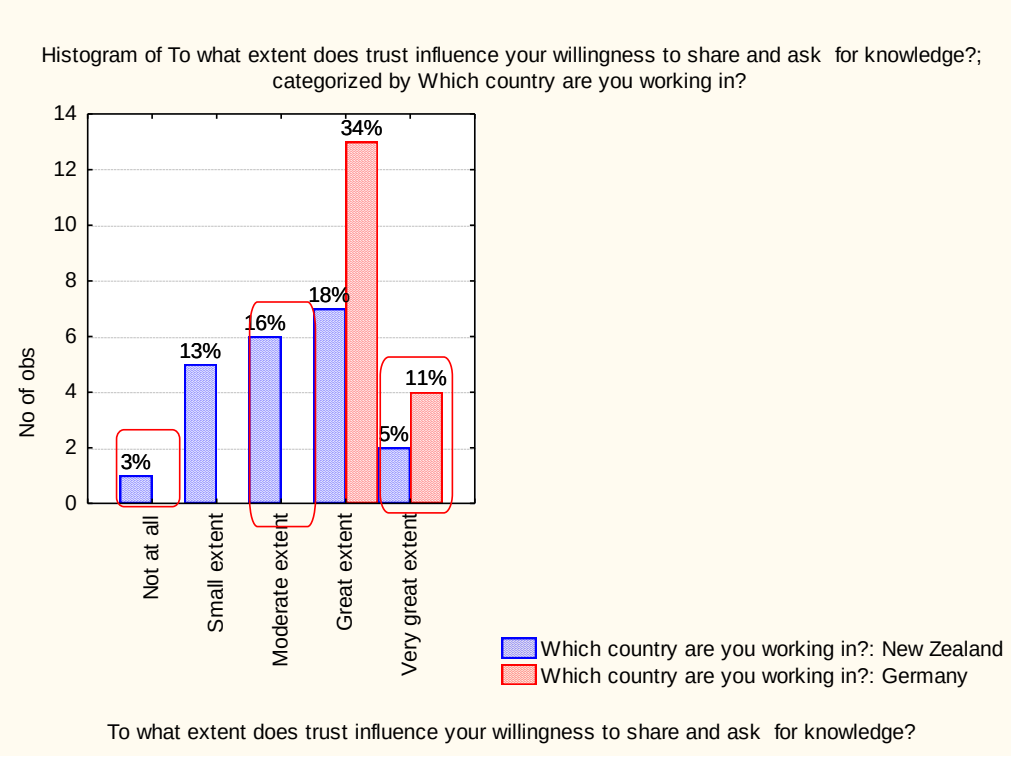

Figure 58: Difference between New Zealanders and Germans regarding the importance of trust for sharing and asking for knowledge.

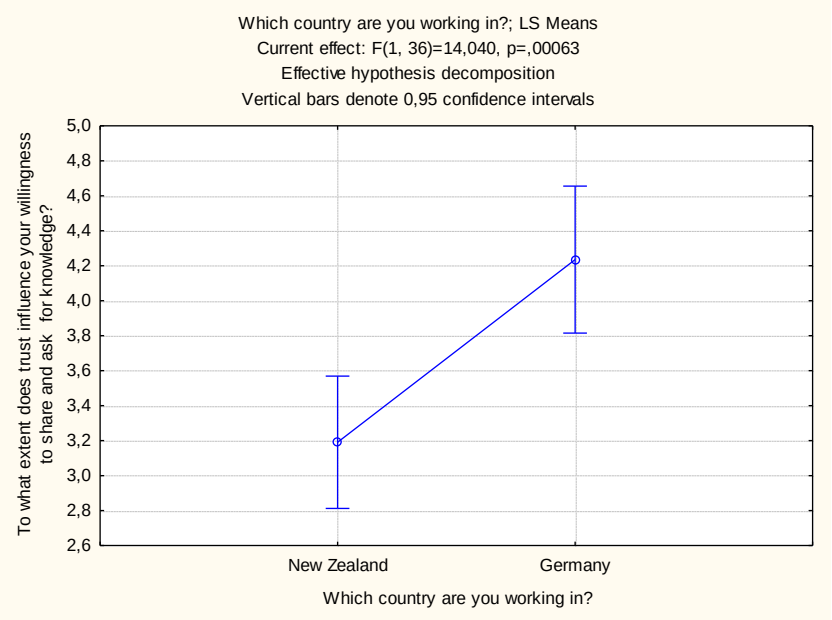

Figure 59: ANOVA for the difference between New Zealanders and Germans regarding the importance of trust for sharing and asking for knowledge.

4.1.23 *WHICH OF THE FOLLOWING ROLES ARE YOU MOST COMFORTABLE PERFORMING IN A PROJECT TEAM?*

As displayed in *Figure 60*, half the respondents felt most comfortable as the leader in a project team, while 22% prefer to be a team-player and 22% are most comfortable to contribute as a specialist.

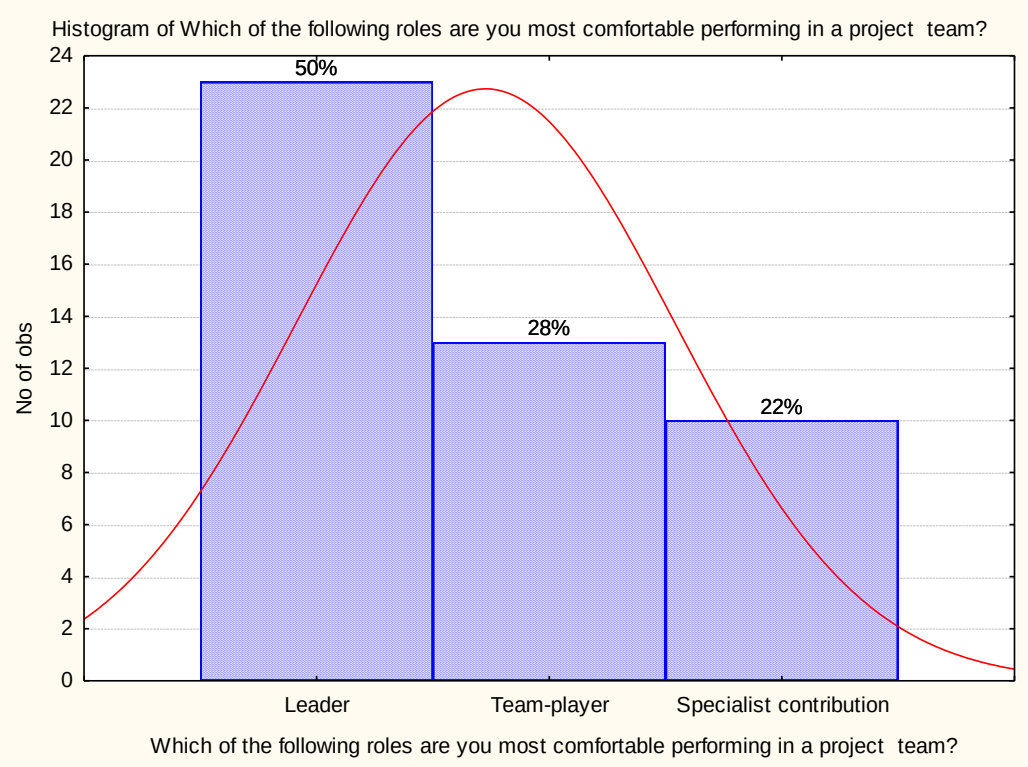

Figure 60: Project team roles that survey respondents felt most comfortable in. Variables involved: Var. 99.

4.1.23.1 Association with willingness to share

The SAL showed an association between survey respondents that feel comfortable in leader roles and a great or even very great willingness to share their knowledge. Also an association between team-players and a great willingness to share was found, see *Figure 61*.

It is surprising that team leaders could be associated with a very great willingness to share knowledge, while team players could only be associated with a great willingness. A successful project is of course beneficial for a team leader and it could be that this awareness increases the willingness to share within the project team. Moreover the team leader could be the person who is considered responsible for the project performance, thus they try to contribute to the success of their team and are very willing to share their knowledge. Also working together in order to reach a goal in a smaller group could increase the feeling of unity and helping each other.

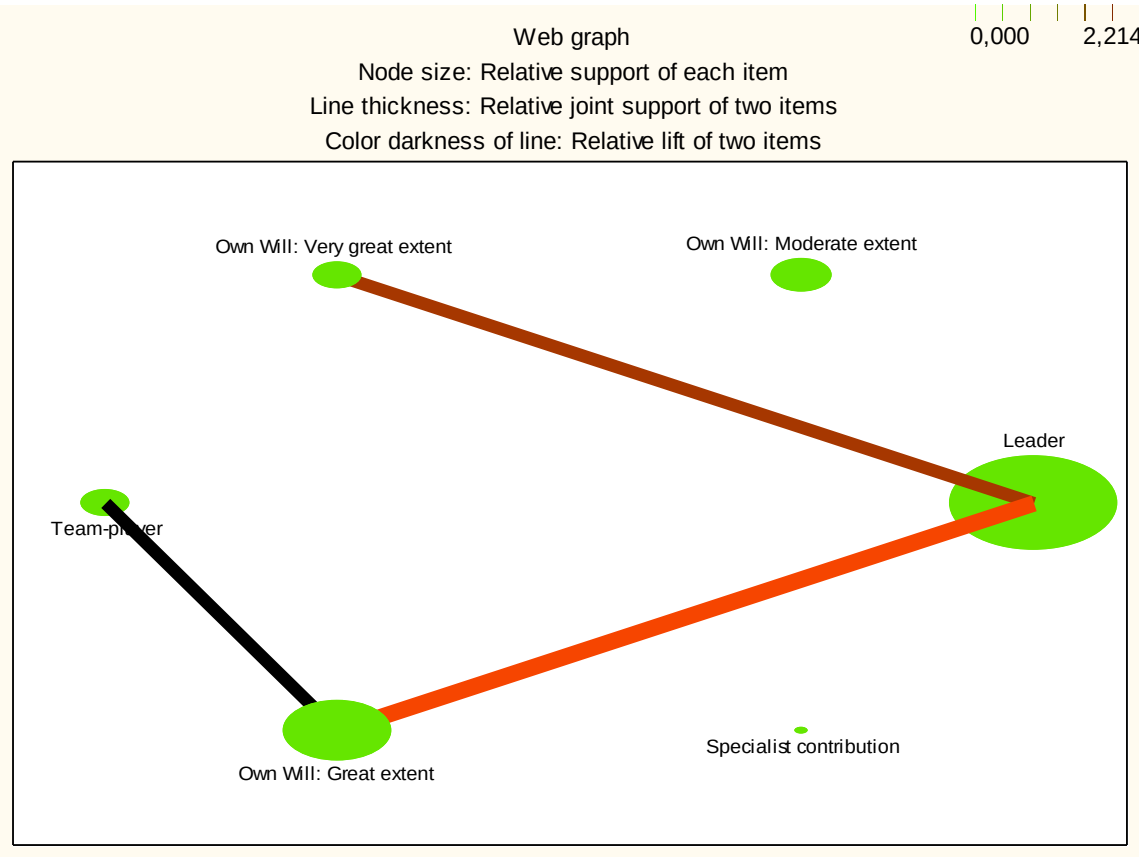

Figure 61: SAL result for the preferred role in a team and the willingness to share knowledge. Min. support 0.1, confidence 0.1. Variables involved: Var. 51, Var. 99. Recogn: Own Will: How would you rate your own willingness to share knowledge within the company?

4.1.23.2 Association with willingness to ask questions

SAL showed that leaders tend to have a great or very great willingness to ask questions. Also an association between team-players and a great willingness to ask questions was found, see *Figure 62.*

It is interesting that team players could be associated with a great willingness to ask questions, while team leaders could be associated with a very great willingness to do so. This is a result that one would expect, as team leaders are supposed to keep an overview over the project and the progress made. It is important for them to stay up to date and to acquire the knowledge relevant to set direction during the project. Also ambition to improve the own knowledge could play a role.

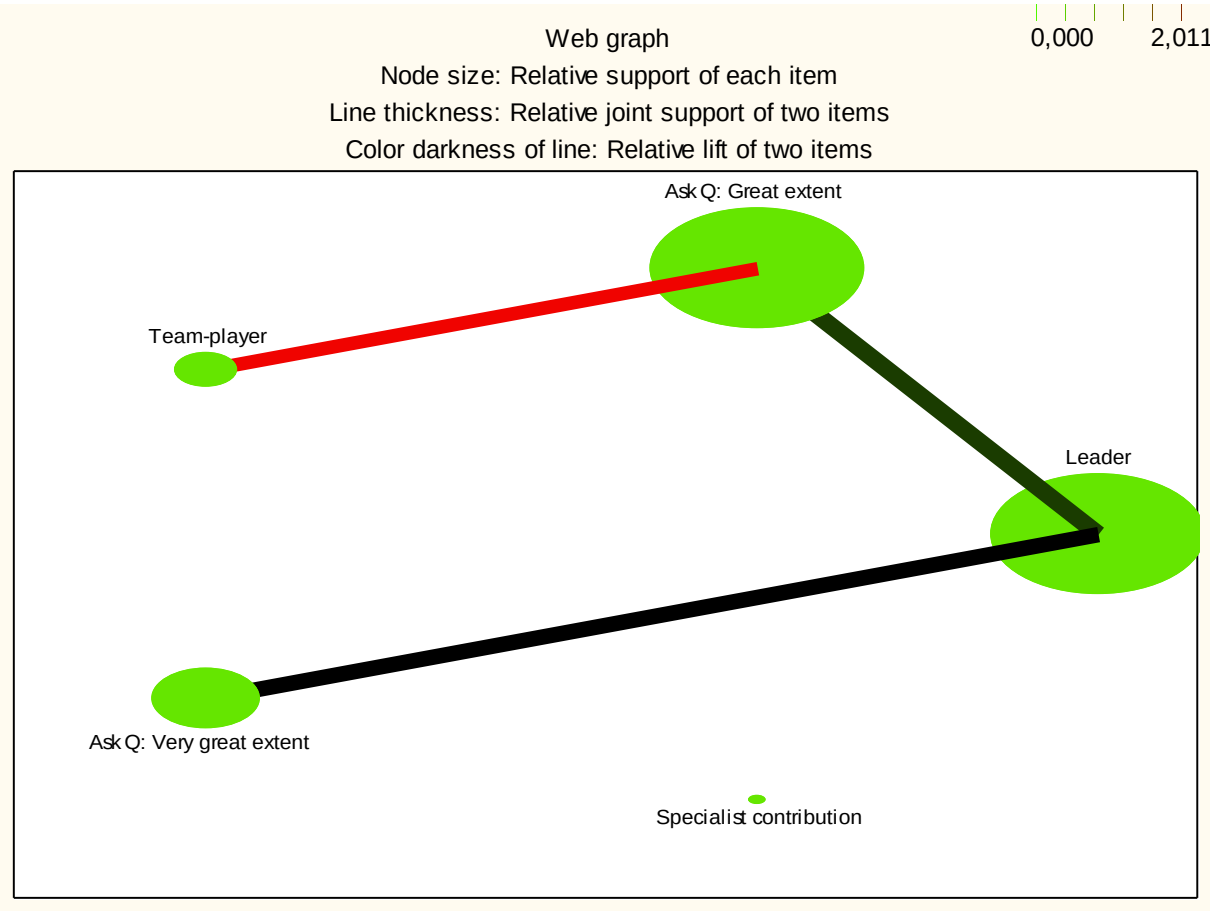

Figure 62: SAL result for the preferred role in a team and the willingness to ask. Min. support 0.1, confidence 0.1. Variables involved: Var. 99, Var. 65.

4.1.24 *How easy do you find it to seek knowledge from superiors, peer and subordinates?*

Seeking knowledge from peers was found the easiest, see *Figure 65*. While seeking knowledge from superiors was considered the hardest, see *Figure 63.*

Implications for practitioners (and managers): It might require active design of organizational hierarchy. If maximum knowledge sharing is the objective, then manager should consider flatter structures, cultural expectations that subordinates bring to their roles (especially in multi-cultural work environments), managers own leadership style and personality factors (e.g. openness and extraversion) of subordinates and managers.

Superiors

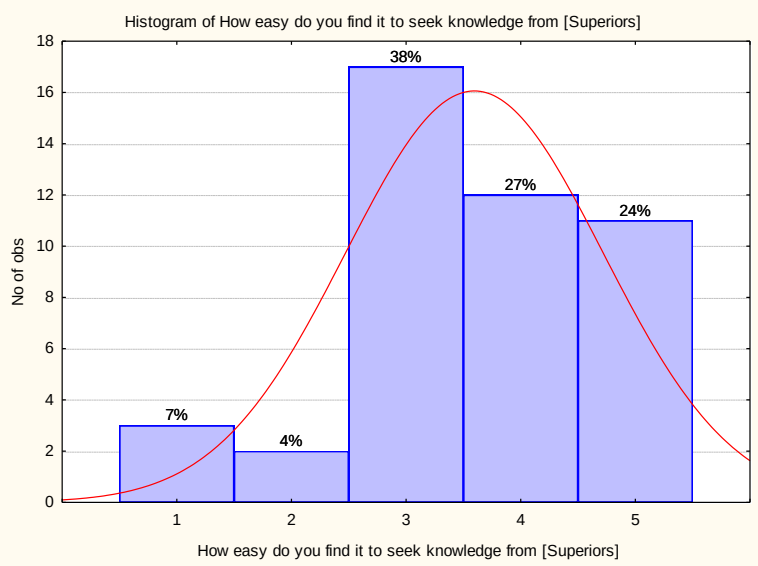

Figure 63: How easy do you find it to seek knowledge from superiors? Variables involved: Var. 102..

Subordinates

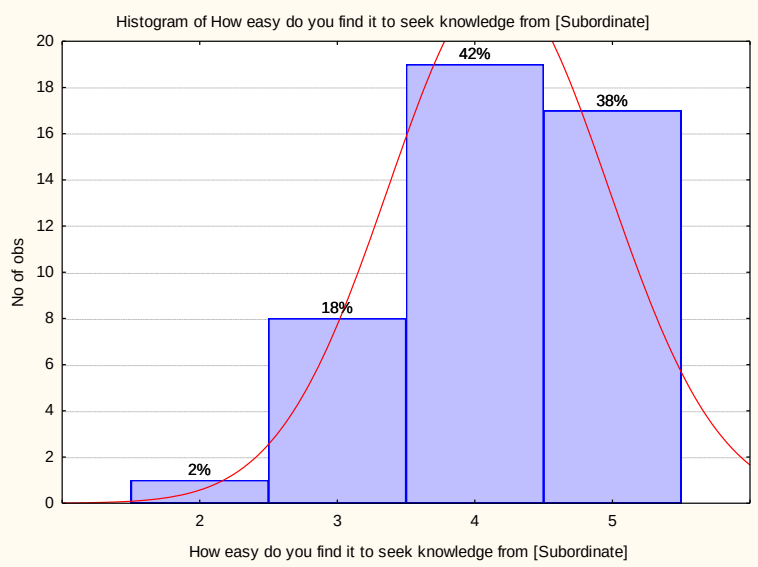

Figure 64: How easy do you find it to seek knowledge from subordinates? Variables involved: Var. 103..

Peers

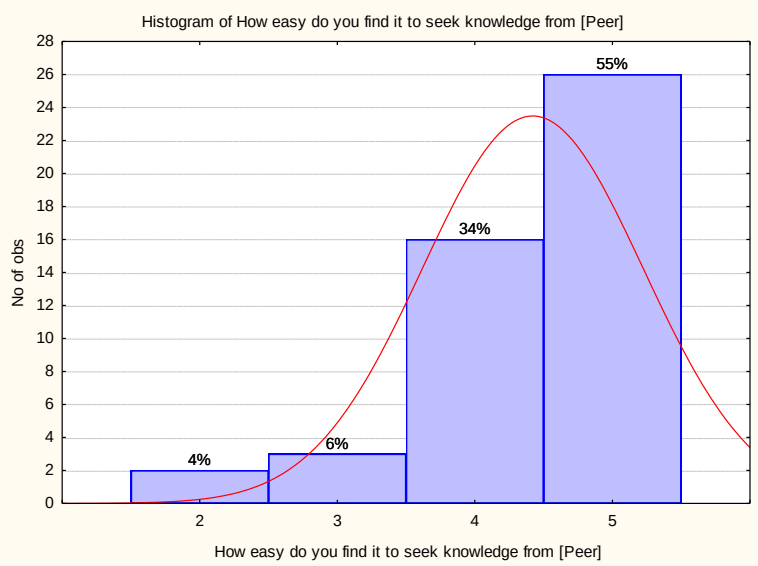

Figure 65: How easy do you find it to seek knowledge from peers? Variables involved: Var. 104.

As shown in Figure 66 and 67, people found it easier to seek knowledge from peers and subordinates than from superiors. While survey participants found it the easiest to seek for knowledge from peers, seeking knowledge from superiors was considered the hardest.

Superiors compared to subordinates:

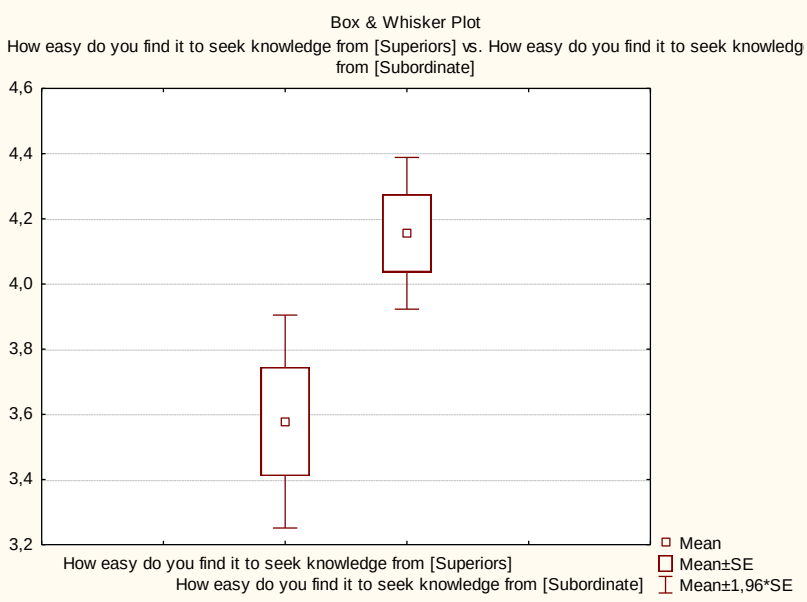

Figure 66: Effort to seek knowledge from superiors compared to subordinates. Variables involved: Var. 102, Var. 103.

Superiors compared to peers:

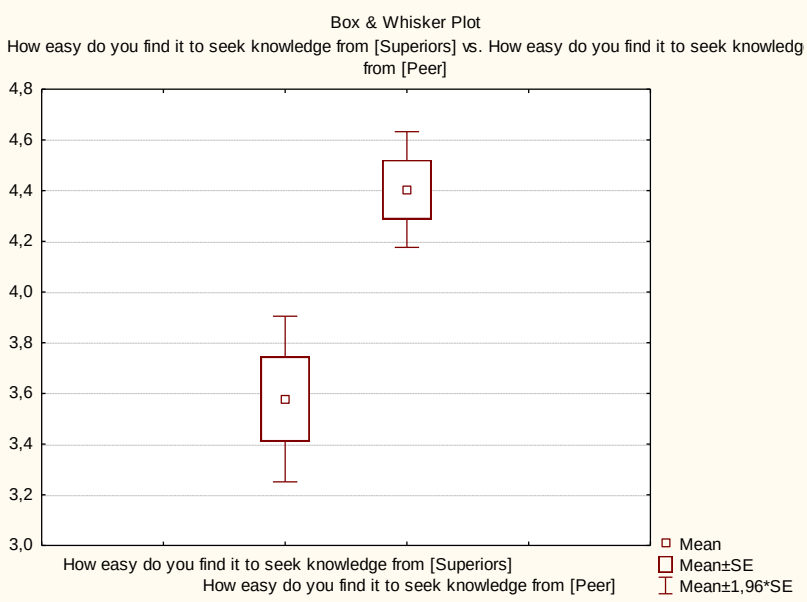

Figure 67: Effort to seek knowledge from superiors compared to subordinates. Variables involved: Var. 102, Var. 104.

The survey respondents found that it was easier to seek knowledge from peers than from subordinates, see *Figure 68.*

Subordinates compared to peers:

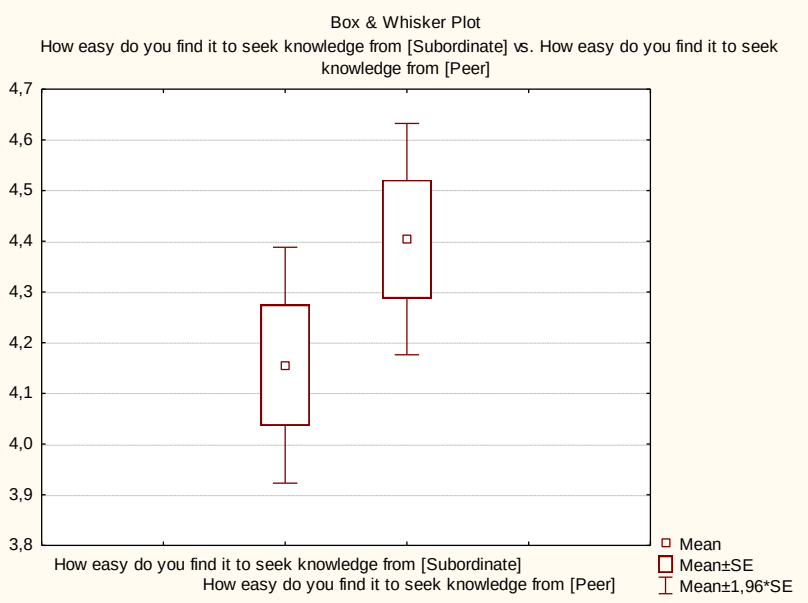

Figure 68: Effort to seek knowledge from superiors compared to subordinates. Variables involved: Var. 103, Var. 104.

4.2 INTERVIEWS

Based on the answers given and the position the survey participants had in their companies, the involvement in NPD processes was rated. Most participants were involved to a great or very great extent in NPD; hence, their opinions are important for this research. See *Appendix D* for detailed interview results.

Awareness of KM (or lack thereof)

Through the interviews it was found that communication was considered highly important within companies or organizations. All participants answered 'definitely yes'. This result supports the findings of a previously conducted survey by Pons ('Project management for professional engineers', Pons 2010, research poster presented at 2010 PMI conference in Wellington). It is interesting that 8 out of the 14 respondents (see gray answers) mentioned at least one KM process when being asked what they associated with communication. That implicates that many people might associate certain parts of KM with communication itself. While Pons' survey pointed out the importance of communication for engineering companies, KM was considered not very important. Maybe the term 'knowledge management' is not very well known. The interviews supported this assumption. Most people seemed to not be familiar with the term 'knowledge management'. Only four interviewed people were sure that they had heard of the term before. Thus it is likely that it is not well known among practitioners. However, all interviewed people, apart from one, found that knowledge management was important for their business to great or very great extent. This shows the importance of KM for NPD companies and engineers involved in the process, thus it is critical to optimize KM practices for the highest possible organizational success.

Personalization strategy with codification strategy support

When being asked which KM strategy people preferred, there was a tendency towards the personalization strategy. Participants felt that the depth of knowledge which can be transferred was higher. The main advantage of codification according to the interview participants was that knowledge was accessible all the time and that personal relationships were irrelevant for the sharing process. However, besides the personal preference of a particular strategy, it was interesting to see that most people pointed out the importance of both strategies supporting each other. No company seemed to put all their emphasis only on one of the two approaches. In companies that applied the personalization strategy a database was either used to find relevant information to acquire common knowledge about a particular topic for discussions or meetings, or to find experts within the organization. In companies where the emphasis was put on the codification strategy, meetings were

still important to further discuss knowledge and work on critical problems. Also employees would approach co-workers to find relevant knowledge in databases. In general both strategies seemed to support each other in every interviewed company.

Management support and culture

Regarding important factors for successful KM the interview results showed that management awareness of KM is essential for its success. Every participant who found that their company used a successful or very successful approach said that management set direction and that there were standards for knowledge sharing. Databases needed to be kept tidy, and in most cases there were people responsible for this particular task. Moreover training or assistance to use the databases efficiently was found important, as well as sophisticated tools to search for knowledge. Formal meetings seem to be important to enforce knowledge exchange between employees of one department or project team, and also between different departments. Overall a culture that encourages knowledge sharing and a clear strategy on how this is to be done seem critical for KM success. The suggestions to improve knowledge management processes varied between participants. One of the most significant issues seems to be a low awareness of KM, its importance and benefits not only among management, but also among staff. While time and a low priority were mentioned a few times, some people also found that co-workers had a low motivation or willingness to share their knowledge. A possible reason for that could be personality factors (e.g. maintaining a certain position as an expert within the organization) or simply a low awareness of the benefits of sharing knowledge.

4.3 SUMMARY: DIFFERENCES BETWEEN NEW ZEALAND AND GERMANY

Perceived overall importance of knowledge

While survey respondents from New Zealand and Germany found that knowledge was definitely important for innovation, some differences regarding the perception of the importance of knowledge were found. Germans tended to rate the importance of knowledge as competitive advantage over other firms higher than New Zealanders. Further they tended to think that increased knowledge results automatically in innovation, while New Zealanders responded more cautiously. This could indicate that knowledge itself is considered more valuable in German companies.

KM practices and encouragements

The survey results showed that the practices in both countries were rather similar. No survey participants from New Zealand or Germany found that their company was not doing anything

regarding knowledge management. However, work-shops and interviews with employees were more common in German organisations, while a communicative work-climate is supported more in New Zealand. Only the difference regarding work-shops was found statistically significant.

On the whole regular meetings and recognition for sharing knowledge seem to be more common practices in German companies. The difference regarding regular meetings is statistically significant.

Reasons not to fully apply KM

Two major differences could be found between respondents from New Zealand and Germany. New Zealanders were more likely to perceive only a low value in using knowledge management practices. But this difference is statistically insignificant. Germans on the other hand tended to find that knowledge management practices were difficult to use, because people tended to be too selfish. No New Zealander mentioned this to be an issue for their knowledge management. This result is statistically significant.

Influence of personal relationships and trust

The survey results showed that the influence of personal relationships was rated significant by respondents from both countries, but it was found even greater in German companies. No German survey respondent found that the personal relationship to their co-workers had only a low influence, or none. Further, people in Germany found that the influence of trust for knowledge sharing is higher than the New Zealanders.

Other differences

New Zealanders tended to be more willing to ask questions than Germans. However, Germans found that they were more extraverted.

Furthermore, the survey results pointed out that companies in New Zealand base their knowledge more on literature than companies in Germany. Knowledge that was acquired during projects and individual knowledge are found to be equally influential.

A survey with a higher number of respondents could possibly show that other identified differences are statistically significant as well.

5 DISCUSSION AND DEVELOPMENT OF A WORKING MODEL

5.1 IDENTIFIED THREADS

Previous parts of this work have examined survey responses and interviewed practitioners. In this section these streams are integrated to produce a conceptual model for successful knowledge management. We identified the following threads:

1. Factors for successful knowledge management

   One of the most important factors for successful KM in NPD organizations was an overall awareness of KM and the benefits thereof. Management and staff need to know the advantages of successful KM and make it a priority for their jobs.

   The results showed that in every surveyed or interviewed company both strategies were applied, personalization and codification. While the emphasis was usually put on one of them, the other one would still be used as support.

   Companies that were associated with successful knowledge management practices did not only apply one particular KM process, but a combination of many; the creation of a database, setting up regular meetings and supporting a communicative work-climate. Moreover three particular methods to encourage staff to share knowledge were associated with KM success; active encouragement to share own knowledge, supporting a communicative work-climate and setting up regular meetings for knowledge exchange. These methods were also associated with a great or very great willingness of employees to share their knowledge. Furthermore KM needs to be given a priority so people have time to share knowledge and the benefits of successful KM have to be known. (See *5.2 Proposed KM success model for NPD.*)

2. Cultural differences

   The purpose of this work was originally not to explore power distance effects. Nonetheless they were found in the survey responses in that the most difficult situation in which to seek knowledge was from superiors. People found it the hardest to seek knowledge from superiors, while it was considered the easiest to seek knowledge from peers. Thus the results show that organizational design and hierarchy structures influence knowledge sharing mechanisms.

3. Influence of trust and personal relationships on knowledge sharing

   The survey results showed that trust and personal relationships have a great influence on knowledge sharing processes between people. This is interesting especially for organizations that put their emphasis on personal knowledge sharing processes. However, the interviews pointed out that even in NPD organizations that mainly apply the codification strategy, personalization is still an important supporting strategy and can by no means be neglected.

4. Factors for unsuccessful knowledge management

   The survey and the interviews showed that KM awareness is essential for KM success, there can hardly be effective knowledge sharing within an organisation without it. If management does not perceive value in using KM practices, it will be hard for staff to share and access previously acquired knowledge. Essential means like a database with a dedicated search tool could be missing and make it very hard for employees to find knowledge.

   Another problem that could result from low management KM awareness is that people might feel like it was not worthwhile to take time for KM. This could lead to a low motivation and willingness to use KM strategies and a low KM priority among staff. Furthermore people might struggle to share their knowledge, if no direction by management is given.

   It was also found that active encouragement of staff through management to share knowledge is important. However, in order to encourage their employees management needs to be aware of KM first. If employees do not feel a climate of trust, they might not be willing to share knowledge either. An overly critical work environment might also result in poor staff motivation to share knowledge.

   If practitioners on the other hand do not perceive value in using KM practices, although the management awareness of KM is high, the results might still be poor. People need to understand what the benefits are for them and the company to share knowledge. It is essential that they know why they should spend their valuable time to use KM practices.

   As the results of the survey and the interviews pointed out that every NPD company used both KM strategies; codification and personalization. It could be assumed that putting a strong emphasis on one of the two while completely neglecting the other might result in poor KM. Both strategies should support each other, while NPD companies with successful KM tended to put their emphasis on one of them.

For particular risk factors regarding both strategies, see *5.2.1 Successful application of codification strategy* and *5.2.2 Successful application of personalization strategy*.

5.2 PROPOSED KM SUCCESS MODEL FOR NPD

For the conceptual model for KM success in NPD organizations, see *5.2.5 Integrative model for successful KM in NPD organizations.* This model shows the overall interactions for KM success in a NPD environment. This model was broken down in smaller models first; see the following sections *5.2.1* to *5.2.4*. All of the models are numbered from KM-1 to KM-6, so it is easy to find them in the KM success model. Vice versa, looking at the KM success model (KM-1), particular models for parts of this model can be found (e.g. KM-4 Conceptual model for successful application of codification strategy).

Summary of the KM models:

- KM-1: Successful knowledge management in NPD organizations
- KM-2 and KM-3: Influence of KM awareness of management on the KM motivation and awareness of employees.
- KM-4: Application of codification strategy.
- KM-5: Application personalization strategy.
- KM-6: Interactions between codification and personalization strategies.

5.2.1 SUCCESSFUL APPLICATION OF CODIFICATION STRATEGY

As already identified, codification refers to storing codified knowledge (e.g. presentations) in a database, typically with an intranet or web front end. Further, as the survey and interview results showed, is codification an important part of KM strategy. But it requires maintenance and is not sufficient on its own in a NPD environment. The personalization strategy must not be neglected (see *5.2.2 Successful application of personalization strategy*).

In order to successfully apply the codification strategy in a NPD organization several criteria have to be met. The required software to create a database needs to be provided by management. The

interview results suggested that this only happens, if management is aware of the benefits of a database and KM in general. Otherwise it seems unlikely that money is invested in this area. Also it was pointed out during the interview processes that it was essential to *keep the database tidy* and well organized. Simply purchasing the software and applying it is not sufficient. Mediocre organization of the database could result in frustration of users and might keep them from using it.

Furthermore, interview results indicated that the *accessibility of the database* has to be ensured. This could be particularly important, if the codification strategy is the company's main strategy for KM. Downtime means that people are not able to access knowledge they might need for the successful completion of their job which could slow the NPD process down and waste time and money. The results suggest that it is necessary that maintenance is done; therefore many firms had people responsible for this task.

But even a tidy and well structured database still requires means to find required knowledge. The interview results suggested that *staff training* could be helpful to ensure efficient database usage. Furthermore *effective search tools* should be available that make it easy for employees to access knowledge.

The process of codifying knowledge and storing it is required for the successful application of the codification strategy, but making this knowledge accessible to employees seems to be just equally important.

The interview results suggested that in order to ensure an efficient codification process, management should give *guidelines for employees to codify knowledge*. People should know how they are required to codify and save their knowledge, as this could make the process more efficient and more popular.

Results also pointed out that the quality of the codified knowledge was an important factor for the success of the codification strategy. Besides guidelines for employees, as mentioned above, a *document control system* could be helpful to ensure quality data. Further, by making KM a priority, managers could *provide time* for their employees to codify and store their knowledge resulting in higher quality database entries. Making KM a priority could also encourage people to use the KM processes, as they might feel like it was worthwhile investing their time doing so.

If the database is well organized, tidy and accessible for employees, plus filled with high quality codified knowledge, it is still essential that people use is. Therefore *active encouragement* by management to use the database could be important.

A conceptual model was created that summarizes this, see *Figure 69*. In general all the factors need to be present.

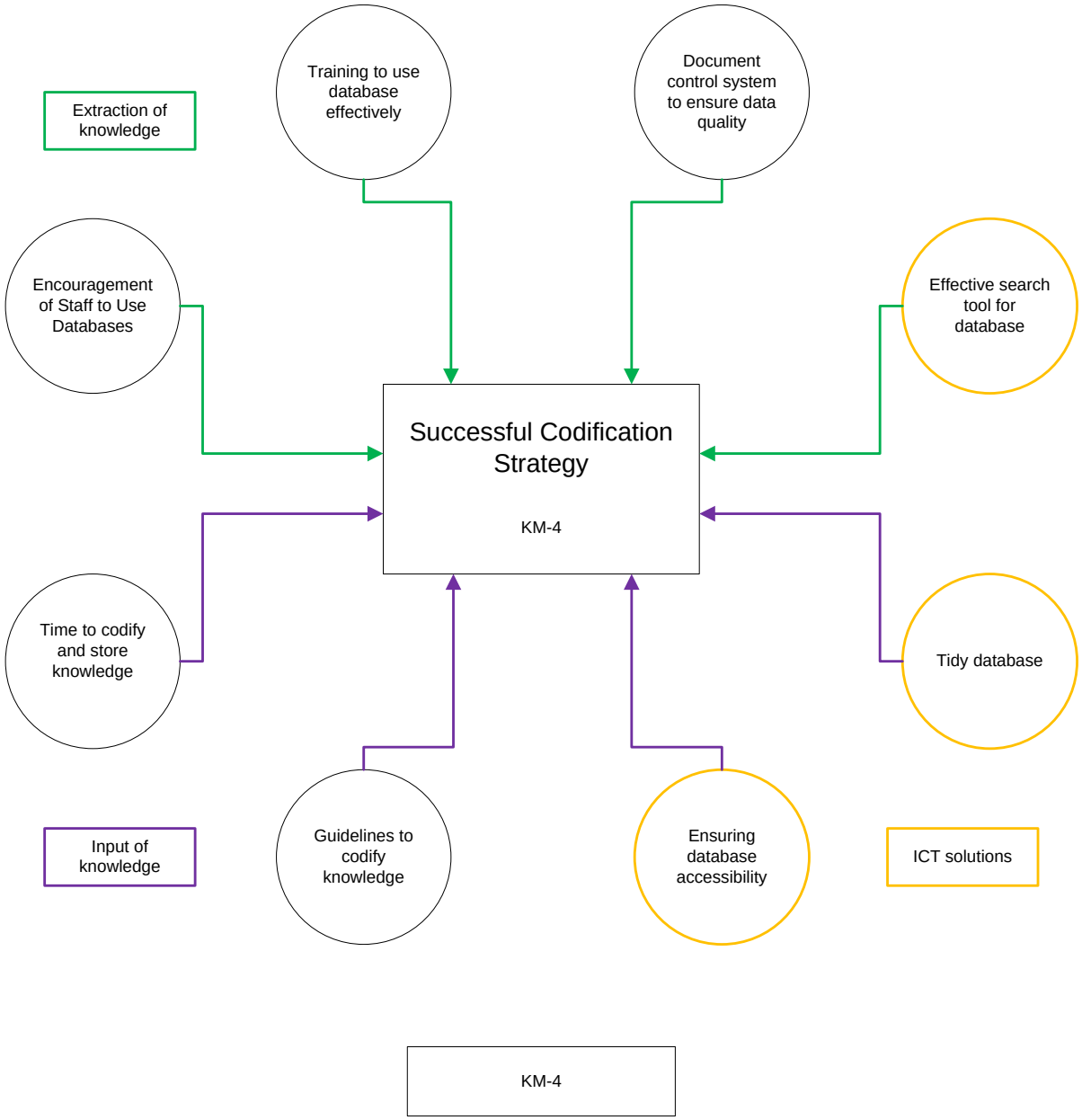

Figure 69: Conceptual model for successful application of codification strategy.

The model in *Figure 69* lays out the different factors for the successful application of the codification strategy. The green lines show the factors that are relevant for the extraction of knowledge; the purple lines show the factors for the input of knowledge. Furthermore, ICT solutions are marked yellow and are relevant for input and output processes. The model displays that they are necessary, but not sufficient on their own.

Major risk factors regarding codification:

- No database at all
- Nobody responsible for database (increased downtime, unorganized and untidy)
- No search tool for database
- Poor quality of codified knowledge (no guidelines to codify knowledge; no document control system to ensure quality data, low priority)
- No time to codify knowledge (low priority)
- No staff training to effectively use database
- Lack of time to use codification processes properly

5.2.2 *SUCCESSFUL APPLICATION OF PERSONALIZATION STRATEGY*

As already described, personalization includes all personal knowledge sharing processes within an organization (e.g. meetings, presentations). The survey and interview results showed that personalization is important for NPD organizations. Furthermore, while codification and personalization are usually both applied for KM in NPD companies, the interview results showed that companies tended to put a stronger emphasis on personalization. Unlike the codification strategy, personalization includes mainly personal sharing processes, thus, different factors were identified as important through the interviews.

The survey and interview results showed that personal relationships and trust have a great influence on personal knowledge sharing processes. This being the case then possible actions to consider are the following: management should consider *supporting a communicative and encouraging work climate*. Employees should be *encouraged to share their knowledge* and therefore could possibly feel more *trust* from management to do so. An overly critical environment should be avoided, as it might discourage people to present and share their knowledge. Potential factors that could *support a communicative work-climate* are, for example, the layout of the work area and a high willingness of employees to share their knowledge.

The support of *informal random meetings* between co-workers to share knowledge and discuss ideas could possibly improve the work-climate. Therefore *time* and suitable locations (e.g. meeting points

for spontaneous discussions) for knowledge sharing processes could be important. Also it might be beneficial to ensure that people who work on the same NPD project are working close to each other and therefore have a chance to communicate easily. Active encouragement to share knowledge and present ideas could also result in a more communicative work-climate.

Active encouragement should also be considered by managers, as it was associated with a high willingness of employees to share their knowledge, which could be very important for personal knowledge sharing processes.

Besides the support of a communicative work-climate, *regular meetings* were associated in the survey with a high willingness of people to share knowledge and KM success as well. The interview results showed that regular meeting are a common and popular KM practice to acquire and share knowledge.

For the successful application of the personalization strategy it is also important that an *emphasis is put on personal relationships*. Managers should consider being particularly aware of personality factors when assigning employees to NPD teams or when employing new staff to make sure they fit well in the team or the organization in general. The influence of personal relationships could possibly be decreased, if people understood the benefits and advantages of KM better, not only for the company, but also for themselves.

Other potentially beneficial practices for the personalization strategy are the creation of *clear protocols of meetings*. The most important results could be written down (codified) and stored, so that others are able to access them.

Depending on the organizational design, *mentor programs* can be a helpful KM practice to transfer knowledge from more experienced staff or experts to new employees. This could be a valuable method to transfer deep knowledge or knowledge that is hard to codify.

As a summary of the text, a model for the successful application of the personalization strategy is shown in *Figure 70*.

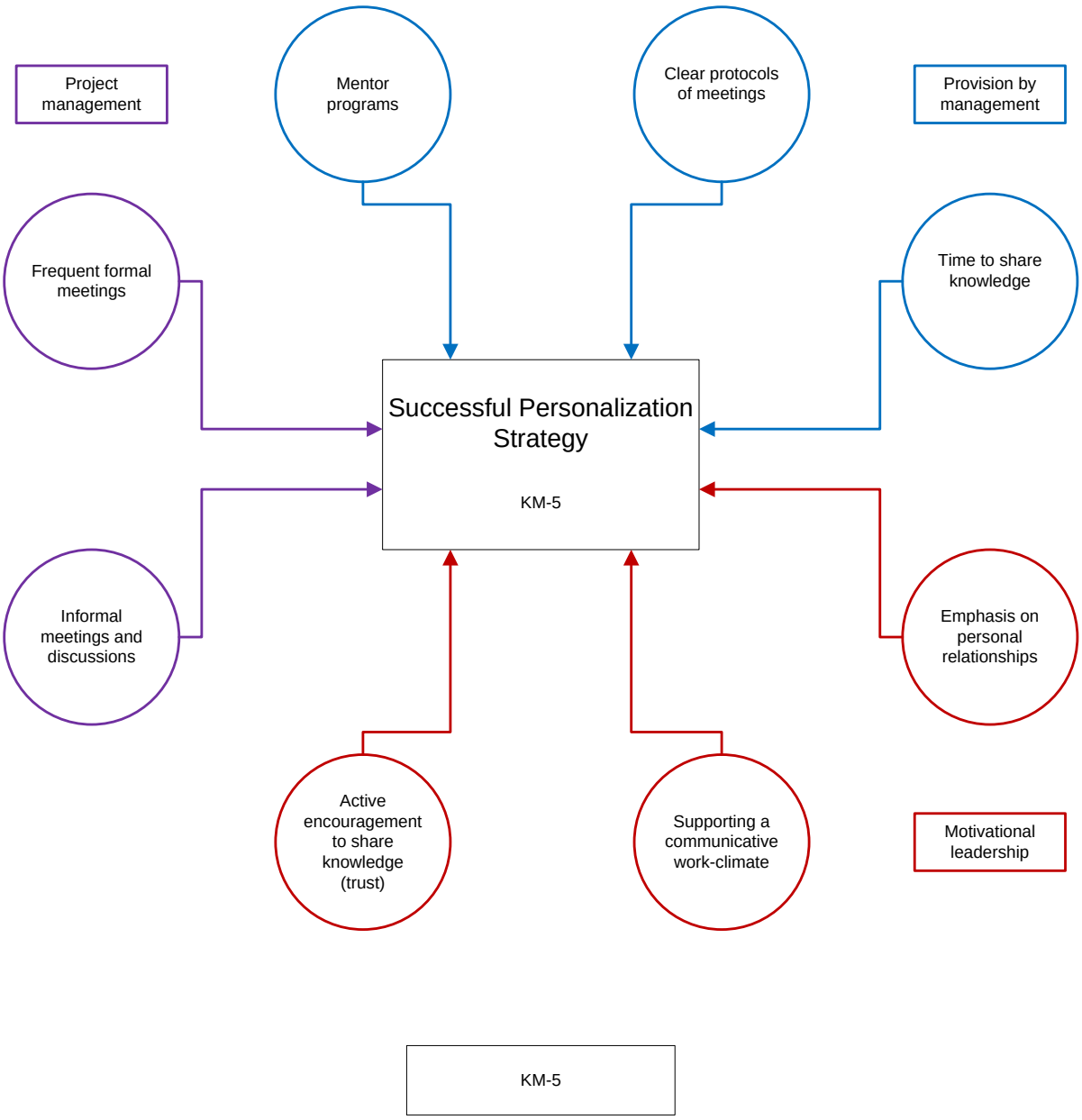

Figure 70: Conceptual model for successful application personalization strategy.

Mentor programs, clear protocols of meetings and time to share knowledge (blue) should be provided by management. *Active encouragement to share knowledge, supporting a communicative work-climate and emphasis on personal relationships* could be considered as part of motivational leadership (red). *Frequent formal meetings* and *informal meetings and discussions* could be associated with project management (purple).

Risk factors regarding personalization:

- No emphasis on personal relationships
- No support of a communicative, creative and climate that encourages knowledge sharing and presentation of ideas
- Lack of frequent formal meetings
- Lack of informal random meetings and discussions
- No time to share knowledge
- No clear protocols of meetings
- No mentor programs
- Lack of time to use personalization properly

5.2.3 *MODEL FOR THE SUPPORT BETWEEN CODIFICATION AND PERSONALIZATION STRATEGY IN NPD ORGANIZATIONS*

As the interview and survey results showed, NPD companies applied both strategies for their KM. In most cases the emphasis was put on one of the two strategies, while the other played a supporting role. A tendency towards a stronger emphasis on the personalization approach was seen.

However, both strategies were identified as important for successful KM in NPD environments. In companies where the emphasis was put on the codification strategy, personalization practices were used as additional support. While a big part of the relevant knowledge was extracted from a database, it was then *discussed* with other employees during formal or informal *meetings*. These *discussions* could be important to further deepen the knowledge acquired through codification. *Meetings* were not only found important to discuss knowledge and ideas, but also to exchange knowledge.

In many cases people also used *personal contacts* to figure out where and how to find the relevant codified knowledge for their job. Thus, the application of codification as a means to acquire knowledge can sometimes start with personalization practices.

In companies with a stronger emphasis on personalization, codification was also found helpful and important. It seemed common practice that people used codified knowledge before meetings or

discussions to acquire relevant knowledge and to get a *common understanding* regarding a topic. Moreover, codification was used to *store major outcomes of meetings and discussions* in order to make it accessible for others. This process could be common to ensure that other experts who might join a NPD team at a later stage during the project can get a common understanding rather quickly by accessing previously codified results of meetings and discussions.

Databases were also used to identify relevant experts within the organization. People might need knowledge in a particular area, find the relevant co-worker in a database and then use personalization practices to acquire the actual knowledge from them.

The conceptual model for the support between the codification and the personalization strategy, which summarizes the text above, is shown in *Figure 71*.

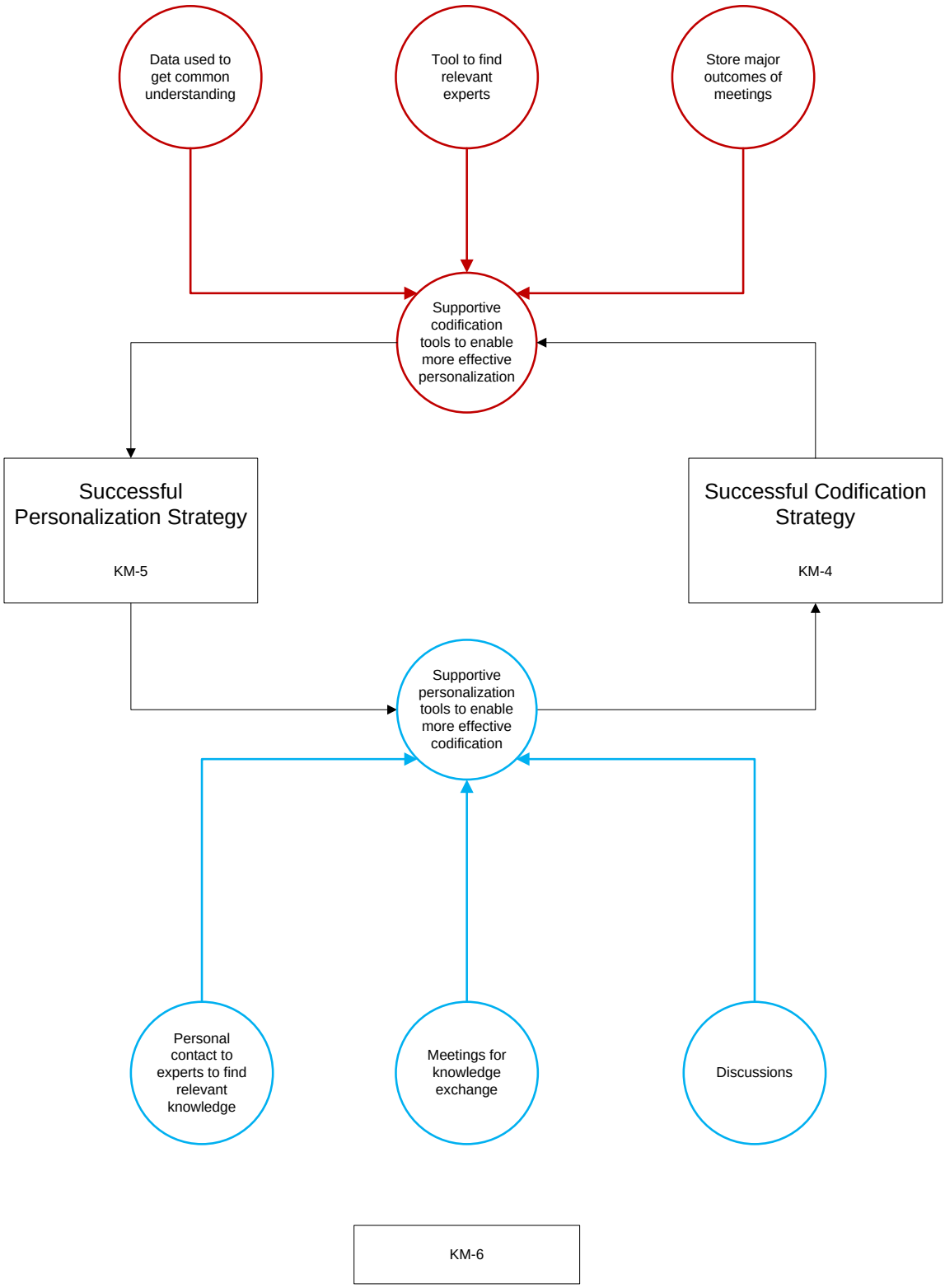

Figure 71: Conceptual model for the support between codification and personalization strategy in NPD organizations.

The top part (red) of the model lays out how codification could support personalization; vice versa the bottom part (blue).

5.2.4 *CONCEPTUAL MODEL FOR THE INFLUENCE OF KM AWARENESS OF MANAGEMENT ON THE KM MOTIVATION AND AWARENESS OF EMPLOYEES*

The interview and survey results showed that the KM awareness of management and staff is important for KM success. Without knowing about the benefits for employees and the organization, it is therefore possible that KM results could be poor. It is also possible that a low awareness would result in unstructured, unorganized KM approaches with poor success.

While KM awareness of employees was found important, interview results suggested that awareness of management was vital for successful KM. If managers are aware of KM, they can stimulate the KM awareness of staff. There are different ways to do this:

- Managers could *provide tools* to enable employees to use KM practices. A tidy, well structured database was found critical, as well as frequent formal meetings for knowledge exchange.

- The results also suggested that managers should *set direction regarding KM*. How is KM supposed to be applied? Which strategies should be used? Answering these questions could help employees to share and access knowledge within the organization. Furthermore it might increase their willingness to do so, as the means would be clearly defined. If the direction for KM is set through managers, it could indicate to staff that there is a particular *KM priority* and spending time using KM practices is worthwhile doing.

- The results of the survey and the interviews also showed that *active encouragement* of staff to share knowledge by management could result in a high willingness of people to do so. Hence, managers should consider *active encouragement* as a way to motivate their staff to use KM practices. People could also feel a higher level of *trust* within the organization which might increase their willingness to share their knowledge and ideas. Results suggest that trust is particularly important for the successful application of the personalization strategy.

- Further, the survey results suggested that *organizational design* can have an influence on knowledge sharing processes, and thus, KM success. Managers should consider flat hierarchies to improve knowledge sharing within the company.

This is summarized in a conceptual model, see *Figure 72*.

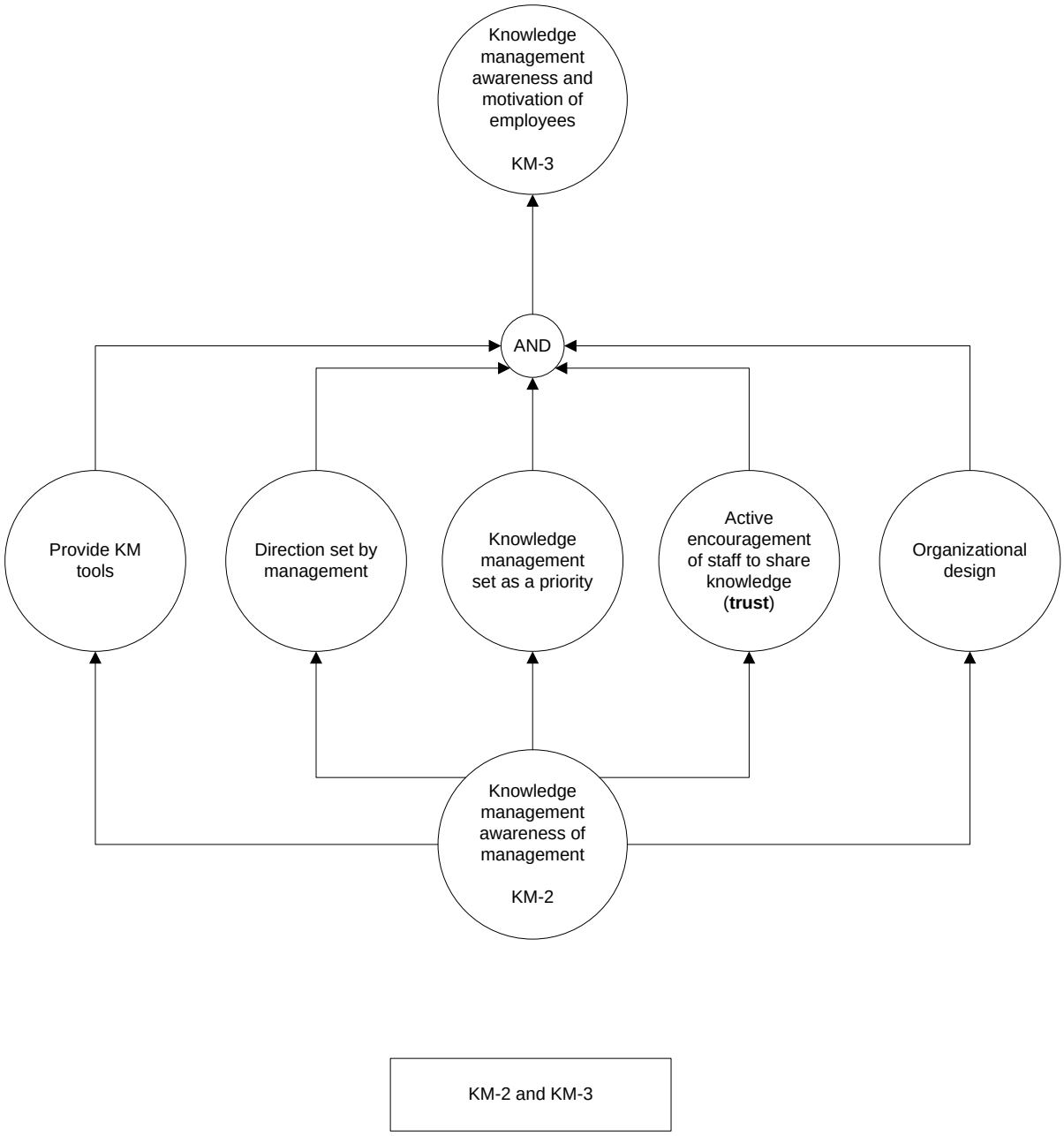

Figure 72: Conceptual model for the influence of KM awareness of management on the KM motivation and awareness of employees.

5.2.5 *INTEGRATIVE MODEL FOR SUCCESSFUL KM IN NPD ORGANIZATIONS*

The previous models (KM-2 and KM-3; KM-4; KM-5; KM-6) explain the important factors for successful KM in NPD organizations. At this point these are all integrated into a larger model, see *Figure 73*.

The interview and survey results suggest that management awareness is essential for successful KM. Managers should provide the general conditions to stimulate staff motivation and awareness for KM. As described in *5.2.4* (*Figure 72*), managers should consider providing tools for KM, setting KM direction, making KM a priority, actively encouraging their staff to share knowledge (creating a climate of trust) and creating an organisational design that supports knowledge sharing. Through these processes employees could be more aware of KM and the benefits thereof. Moreover their motivation to use KM practices could be higher. The results of the survey and the interviews pointed out, that staff motivation and awareness of KM was an important factor for KM success.

Furthermore, the survey and interview results showed that NPD companies applied both KM strategies; codification and personalization. The emphasis was usually put on one of the two while the other one was used as a support. The support mechanisms between the two strategies are explained in *5.2.3 (Figure 71)*

A tendency towards personalization was identified. The factors for successful codification and successful personalization are shown in *5.2.1 (Figure 69)* and *5.2.2 (Figure 70).*

These various elements are integrated into the larger model of *Figure 73*.

The central concept of this model is that successful knowledge management for NPD requires means for personalization and codification, the awareness of employees, and management support. All of these reinforce each other. Furthermore, if current KM practices are mediocre or non-existent, then the place to start is with management, specially the raising of their awareness.

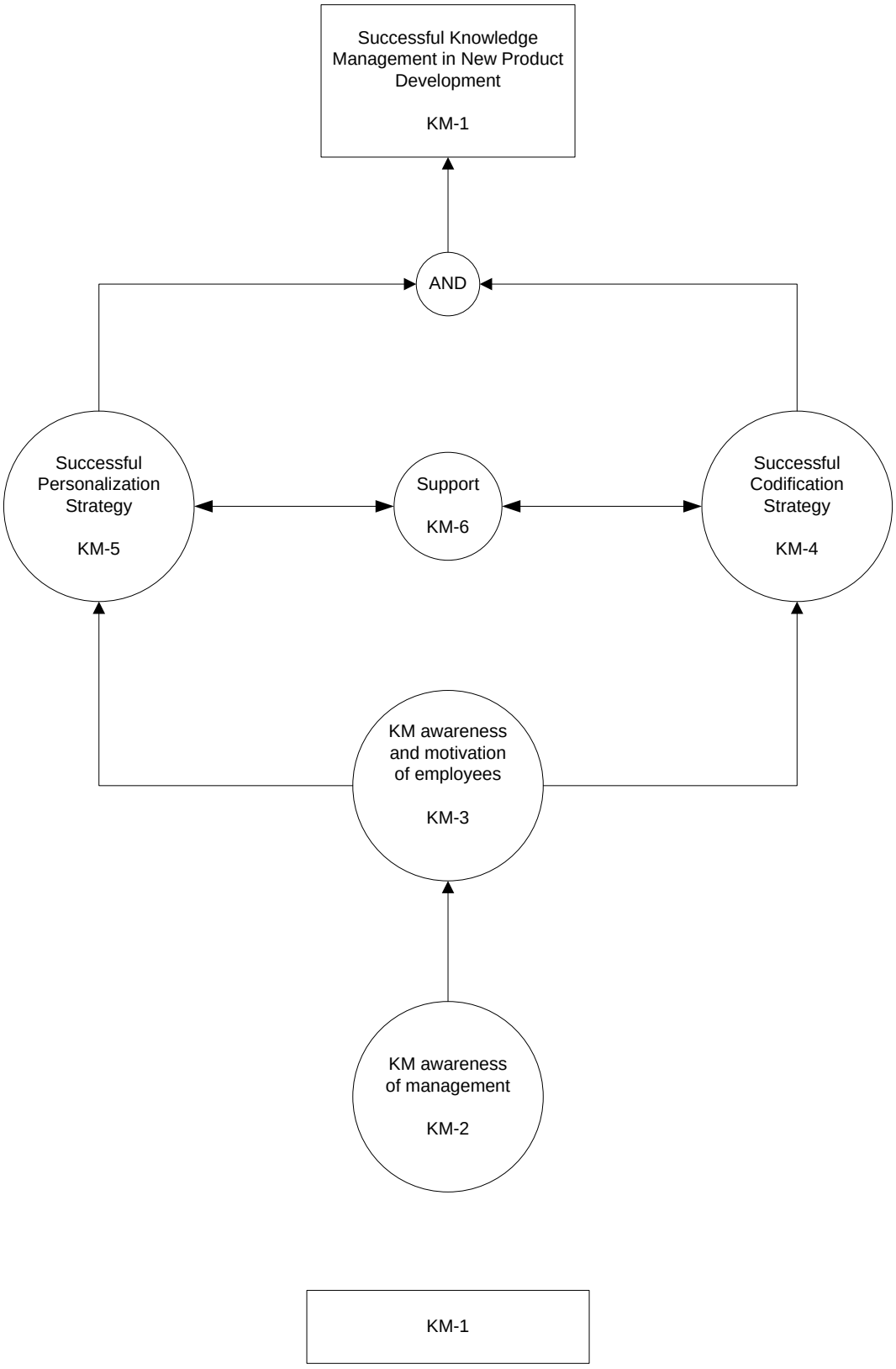

Figure 73: Integrative model for successful KM in NPD organizations.

5.2.6 *INTEGRATION WITH EXISTING APPROACHES TO KNOWLEDGE MANAGEMENT*

ICT Solutions

One of the common approaches to KM is ICT solutions (e.g. database, search tools, network drives, and wikis). As this model shows, ICT solutions on their own are necessary, but not sufficient for successful KM.

Design Theory

Existing design theories, e.g. (Hubka & Eder, 1996; Pahl & Beitz, 1988), tend to emphasise the technical problem solving. This model shows that there is a significant amount of personal interaction within the design team that should be considered.

Project Management

The main focus of project management is determining what deliverables are required, and then anticipating the work tasks required to get there. As this model shows, a successful NPD project is not necessarily a fresh start every time, but instead builds on the consolidated knowledge from previous projects. Thus KM has the potential to be the mechanism that links the projects together over time to create organizational success.

5.3 IMPLICATIONS FOR PRACTITIONERS

Respondents overwhelmingly (72%) perceived knowledge to be important for innovation, and that it provided a great or very great competitive advantage (97%). Curiously, Germans believe the latter significantly more strongly than New Zealanders. The reasons for this are not known: possibly NZ is not exposed so directly and explicitly to competition as Germany, or its products are not the type that have competition. Another national difference was that Germans tended to think that increased knowledge results automatically in innovation, while New Zealanders responded more cautiously. This shows again that the overall importance of knowledge for innovation might be perceived higher in German companies. Companies in New Zealand tended to base their knowledge more on plain literature (as opposed to personal knowledge) than companies in Germany.

However, most respondents felt that only a moderate KM success was achieved. This suggests that it may be difficult to fully apply the potential of KM. The results show that merely creating a database is insufficient for highly successful KM: regular meetings and a communicative work climate are also important. The most important reasons for employees not to fully use KM practices are too much effort and time to do so. Certain existing knowledge capture methods, e.g. interviews, are cumbersome and costly in time, and the result implies that better and more efficient methods for capturing and accessing knowledge are required. Most companies tended to not measure their intellectual capital formally. By implication, either their assertions of the importance of knowledge are superficial, or more likely, the type of knowledge is insufficiently explicit to be recorded as intellectual capital. This is consistent with Nonaka's assertion that much knowledge is tacit. Therefore there may be limited value in deploying methods for *measuring* intellectual capital, at least with current measures.

On the whole the survey and interview results showed that for successful knowledge management an overall awareness of KM itself is essential. Executives, project managers and project team members have to be aware of the benefits and advantages of successful KM. However, the implications for each group vary and were therefore laid out separately.

5.3.1 *IMPLICATIONS FOR EXECUTIVES*

As mentioned above, an overall KM awareness is important for successful KM. However, the KM awareness of executives might be one of the most important factors for KM success.

The survey and interview results suggested that executives should set direction regarding KM. They should decide on the overall KM strategy that should be applied within the company. It was found that in NPD organizations both KM strategies, codification and personalization, were applied. But a tendency towards personalization was identified. A particularly strong emphasis on one strategy, while neglecting the other one, could increase the risk of unsatisfying KM results, and should therefore be avoided. Furthermore executives should consider ensuring a level of support between both strategies (see *Figure73: Integrative model for successful KM in NPD organizations*).

Executives should also consider providing the necessary tools for the application of KM. This could include relevant software to set up a database, intranet or wiki within the company. Sophisticated search tools were identified particularly important for an efficient codification approach. Also executives should consider assigning particular employees responsible for the structure and tidiness of the database.

As the survey results showed that NPD companies in New Zealand base their knowledge stronger on literature than companies in Germany, executives in New Zealand should make sure that their KM processes provide methods to aggregate literature.

For the successful application of the personalization strategy it could be important that executives put a high emphasis on the recruitment process of new staff to ensure their suitability for particular departments or project teams, because interview and survey results pointed out the high influence of personal relationships on knowledge sharing processes.

In general executives should consider ensuring that the importance and the benefits of KM are well understood in their organization, as this could increase the motivation of staff to apply KM practices. People might be more willing to invest time in KM processes and feel like it was worthwhile doing so.

Educating project managers and staff, for example in work-shops, about the benefits of successful KM could help to increase KM awareness and the motivation to apply KM practices.

Executives should be aware of human resource incentives as the interview and survey results also showed that these incentives can have an influence on knowledge sharing within the company. It is possible that certain HR incentives suppress knowledge sharing.

Some power distance effects were noticed as well, thus executives should consider flatter structures to support knowledge sharing processes. This might require active design of organizational hierarchy.

Main risk factors for executives:

- Low KM awareness
- No direction set regarding KM strategies
- No tools and means for KM provided
- KM importance and benefits unclear within the organization which may result in poor staff motivation for KM practices

5.3.2 IMPLICATIONS FOR NPD PROJECT MANAGERS

As the interview and survey results suggested, KM awareness is particularly important for KM success. Project managers need to be aware of the benefits of successful KM and should consider educating their team about the potential advantages and the importance of KM as well. This could increase the motivation of team members to use KM practices.

Especially when the company's KM emphasis is put on the personalization strategy, project managers have to be aware of personal relationships between their team members to avoid knowledge sharing issues. Project managers should take extra care when building the project team and try to ensure a good work-climate. Educating the project team about the benefits of KM for the team itself and each member might decrease the negative influence of difficult personal relationships.

In bigger project teams that include different work groups it could be worthwhile encouraging members of each work group to present ideas and major findings at an early stage of the NPD process to the whole team. This might ensure that people feel like they get recognition for sharing their knowledge and assure them that the project manager is aware of their contribution to the project.

Particular encouragement methods were identified through the survey and the interviews that could increase the overall motivation of team members to share their knowledge. These methods were not only associated with a higher willingness of people to share knowledge, but also with a great KM success and should therefore be considered by project managers:

- Supporting a communicative work climate
- Setting up regular meetings for knowledge exchange
- Active encouragement to share knowledge

Certain KM processes were also associated with KM success, and could be important for project managers to consider:

- Creating a database (tools provided by executives)
- Regular meetings for knowledge exchange
- Support of a communicative work climate

Supporting a communicative work-climate and regular meetings for knowledge exchange were identified important KM practices and knowledge sharing encouragements and therefore are considered particularly essential in NPD projects.

Project managers should further be aware of the influence of power distances on knowledge sharing processes and consider their leadership style, personality factors (e.g. openness, extraversion) and cultural expectations.

The results show that a personal willingness to share knowledge (something the Germans were less inclined to do that the New Zealanders) requires active intervention by managers. Specifically, the creation of a communicative work climate, regular meetings, and active encouragement to share knowledge. Human interaction of a personable type emerged as important: people are more willing (74%) to share knowledge *within* their workgroup than with the wider organisation, and with people they trust. This is important in NZ, and particularly important in Germany. The implication for managers is that workgroups are important. The corollary is that it may be difficult to create this type of collegiality in project-based organisations where the allocation of staff to work streams is dynamic. Thus project managers will probably need to take specific care in creating a workgroup if they wish to see effective knowledge sharing occur in their teams. This is potentially challenging, as the existing project management methods, e.g. PMBOK, tend to emphasise the utilitarian value of the worker as a unit of labour, and optimise that utilisation rather than knowledge-sharing. We thus tentative suggest that temporary project-based organisational structures might not be the best for NPD.

Another implication for managers is that people find it significantly harder to seek information from superiors (compared to peers or subordinates). Therefore managers who wish to make their knowledge available to subordinates will need to take particular care to create the opportunities for that to happen.

Risk factors for project managers:

- Low KM awareness (low perceived value of KM)
- No KM direction set within the project team
- KM importance and benefits unclear within the project team
- No active encouragement of staff to use KM practices
- No climate of trust where employees feel encouraged to share knowledge and present ideas
- No awareness of the influence of personal relationships on KM
- Overly critical work environment
- No (or too few) regular meetings
- No use of database among the project team
- Lack of time for knowledge management principles

5.3.3 IMPLICATIONS FOR ENGINEERS

The interview and survey results showed that KM is highly important for engineers involved in NPD. Therefore engineers should contribute to the KM process within their organization and be aware of the advantages for them, the project team and the company. A high motivation to use the KM practices is important for KM success.

Since personal relationships were identified particularly important for personal knowledge sharing processes, engineers should try to maintain a good work climate in which co-workers share their knowledge. This could require a high willingness of people to share their own knowledge and to ask for knowledge that others possess. Being aware of the benefits of KM, engineers in NPD project

teams should also be professional regarding KM and not allow personal conflicts to decrease their motivation to share knowledge with others or to ask questions to acquire knowledge.

However, particularly for engineers involved in NPD the time pressure during projects can be very intense. Thus, a lack of time to use KM properly is one of the most critical risks for KM itself.

Risk factors for engineers:

- Low KM awareness
- Low motivation to use KM practices
- Strong negative influence of personal relationships to co-workers
- Poor willingness to share own knowledge
- Poor willingness to ask questions to acquire knowledge
- Lack of time to use KM properly

5.4 LIMITATIONS OF THE WORK

This work examined KM in NPD organizations from an engineering point of view. Therefore the IT perspective on KM in general is limited.

Furthermore the number of survey responses was relatively low (55 completed surveys). Potentially more results can be found through a survey with a higher number of participants. Some differences between New Zealand and Germany might also be identified more as significant if the sample size was larger.

Though the emerging conceptual model for successful knowledge management is relatively simple, and the constructs might even seem simplistic, the work nonetheless sets a foundation for potential future work in that it identifies that the statistical effect-sizes are small (which is useful in planning future data-gathering exercises), and it identifies which variables are more (or less) important.

5.5 IMPLICATIONS FOR FURTHER RESEARCH

Deeper relationships

The results of the survey and the interviews in particular showed a tendency of NPD companies towards the personalization strategy. But one could have expected that one of the two strategies might be more dominant. A survey with a higher number of participants might be required to fully examine this result.

Work-climate

Moreover, more detailed research as to active encouragement and the support of a communicative work-climate could be done. What is the best way to actively encourage people to share their knowledge? Does this mainly imply incentives and recognition for sharing knowledge or can project managers use other strategies? And what in particular do people consider a communicative work-climate? Do they wish more informal meetings between co-workers; should managers consider approaching staff more frequently to get information on NPD findings? How relevant is the layout of the office? Do people think that the work climate in their organization is good, if co-workers share their knowledge with them or if they have good personal relationships with them? Which factors are most important?

Organisational design

A possible future field of further research could be to examine different organizational designs and to compare their KM success, thus, to research hierarchy structures that are particularly suitable for the distribution of knowledge within NPD companies. Also it could be interesting to research KM practices and specifically capture some of the cultural variables.

Trust

It could be worthwhile researching what influences people's perception of trust in an NPD environment. What are the associated fears that keep people from sharing their knowledge when they feel a low level of trust? And what do employees think could be done to improve the level of trust in their organization? Is there anything that could help to improve personal relationships and a good communicative work-climate (e.g. special work-group trainings)?

Formal IC measures

Most companies tended to not measure their intellectual capital formally. Although it is assumed that poor IC measuring is no impediment to KM success, at least for moderate success, this needs to be further researched.

Formal knowledge capture processes

Another research question that might be worthwhile answering is: Why do almost half of the surveyed companies only use formal knowledge capture processes to such low extent? There are four different approaches to explain this:

1. Ignorance: could be solved through training.
2. Irrelevance: better methods need to be researched.
3. Unreliability: better methods need to be researched.
4. Lack of time: simpler and quicker tools need to be developed.

Knowledge management is important for organizational success and yet there is still a lot that is not particularly well understood, for example human interactions and their influence on KM.

6 CONCLUSION

How have the original research questions been addressed? The questions were:

a) Is knowledge considered important for innovation and new product development (NPD)?

b) What do companies in New Zealand do, if anything, to store acquired knowledge? And if they don't do anything, why is that?

c) What would encourage engineers to share their knowledge in NPD projects?

d) What are the implications for practitioners?

e) Are there any particular practices that result in successful knowledge management (KM)? And what are the potential problems they might want to keep an eye on?

These questions were addressed by surveying and interviewing engineers and project managers of NPD companies. The acquired data was then analyzed and the results showed that:

a) Knowledge was definitely considered important for innovation. However, differences between New Zealanders and Germans were found. Germans tended to think that increased knowledge automatically resulted in innovation, while New Zealanders responded more cautiously. German survey respondents also rated the overall importance of knowledge higher than New Zealanders by responding more positive regarding knowledge as a competitive advantage over other companies.

b) The survey and interview results showed that all NPD companies used codification and personalization strategies for their knowledge management, hence, to store knowledge and to make it accessible. Codification was identified as an important means to store codified knowledge (e.g. presentations, reports) in a database or a network drive. Furthermore, all NPD companies used personalization practices which are also a way to store knowledge, as it is passed on from one employee to the other through personal interactions (e.g. meetings, discussions).

c) Based on the interview and survey results, the main implications for practitioners are that an overall awareness of KM and the benefits thereof for the company itself and the employees are important for successful KM. The implications for practitioners were categorized: implications for executives, NPD project managers and engineers. Executives should consider setting direction, providing the required tools for KM, making KM a priority, and actively encouraging knowledge sharing processes. Further, they should be aware of organizational design factors and their influence on personal knowledge sharing mechanisms. NPD project managers should consider educating their project team regarding KM and making it a priority. For the successful application of personal knowledge sharing processes it is especially important that project managers are aware of personal relationships and potential issues among their team members. In order to achieve a high willingness to share knowledge within the project team, project managers should consider supporting a communicative work-climate, setting up regular meetings for knowledge exchange and actively encouraging their engineers to their share knowledge. These methods were associated not only with a high willingness of employees to share knowledge, but also with KM success in general. Engineers who work in NPD projects also need to be aware of the benefits of KM. They should consider contributing to the KM process by applying the company's KM strategy and by having a high willingness to share own knowledge and ask questions to acquire knowledge. Furthermore engineers need to be aware of personal relationships with their colleagues and try to maintain

a good work-climate, as this could affect personal knowledge sharing processes within the NPD project team.

d) Companies that were associated with successful KM did not only apply one particular KM process, but a combination of many. Through the interviews and the survey particular KM practices and knowledge sharing encouragements were associated with KM success; the creation of a tidy, well structured database, regular meetings for knowledge sharing, supporting a communicative work-climate and active encouragement of staff to share their knowledge. Thus, NPD companies generally used both KM strategies; codification and personalization. A tendency towards a stronger emphasis on personalization was found. The major problems were a low KM awareness and motivation, low perceived value of KM, no clear strategy as to how KM should be applied within the company, and a low awareness of the influence of personal relationships on knowledge sharing processes.

Furthermore, power distance effects on knowledge sharing were found, as survey respondents thought that the most difficult situation in which to seek knowledge was from superiors, while the easiest was from peers. Thus organizational design and hierarchy structures could have an influence on KM.

The results pointed out that personal relationships between colleagues were very important for knowledge sharing processes within the organization. But also a strong influence of trust was identified. This influence was found even more significant by Germans than New Zealanders.

Through the survey and interviews factors for the successful application of the codification and the personalization strategy were identified. Interactions between both strategies were found. Furthermore the influence of KM awareness of management on the KM motivation and awareness of staff was examined.

The intellectual contribution of this work is firstly the combined use of survey and interviews to explore knowledge management, secondly the focus on the intersection between knowledge management and new product development, thirdly the investigation of the New Zealand practices regarding knowledge management for new product development, fourthly the application of the specific statistical method of association rules to this area, and fifthly the construction of an integrative model for KM success that integrates important KM factors.

APPENDICES

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APPENDIX A: KM SURVEY QUESTIONS

University of Canterbury Research: Successful knowledge management practices

The objective of the survey is to determine the actual practices of industry regarding use of knowledge management in engineering new product development.

Dear Participant,

You are invited to participate in a research study conducted by Volker Wochele (Student of Master of Engineering) and supervised by Dr. Dirk Pons from the Mechanical Engineering Department of the University of Canterbury in Christchurch, New Zealand.

Contact

dirk.pons@canterbury.ac.nz
volker.wochele@pg.canterbury.ac.nz

Purpose of the study

The objective of the survey is to determine the actual practices of industry regarding use of knowledge management in engineering new product development.

We have a particular interest in better understanding actual industry practices and comparing New Zealand practices with common practices in companies overseas. Although it is widely acknowledged that knowledge is a valuable competitive advantage, can save time and money, and can minimize redundant work, the actual practices of firms is less clear.

Therefore we seek to better understand which knowledge-management (KM) practices are actually in use; impediments to implementation; perceived value of knowledge; team effects that may constrain knowledge transfer; organisational constraints.

The results of this research will be published in an academic report and possibly also a paper and presentation to learned society/professional institution. We expect that the results will have implications for practitioners in the field of new product development, particularly those involved with innovative products.

Potential Risks and Discomforts

There are no foreseeable risks or discomfort associated with this study.

Confidentiality

Any information that you provide will be treated as confidential. Only the principal researcher and the supervisor will have access to raw data. Even then, all answers and information from participants will be collected anonymously. Data will only be presented in aggregated form in research reports, presentations, and papers. There will be no disclosure of individually identifiable data to other parties.

The survey is done on-line using reputable survey software that preserves anonymity. IP addresses are not collected or obtained during the process, hence it is not possible to trace back the answers of participants. Names and contact details are not collected as part of the survey. The survey data will be stored on password-protected computers.

Participation and Withdrawal

You can choose whether or not to be in this study. If you agree to participate, you may withdraw at any time before submitting the last page. You may also decline to answer any questions you do not want to answer.

The survey should take about 30 minutes to complete.

Rights of research subjects

This proposal has been reviewed and approved by the Department of Mechanical Engineering, University of Canterbury. If you have any questions or concerns about this research, please contact the supervisor Dr. Dirk Pons (dirk.pons@canterbury.ac.nz).

Instructions (please read carefully)

It is possible that not all questions apply to your particular case. Whenever you feel that the question is not relevant to you (i.e. not applicable), please SKIP the question.
You may find that some questions are relevant to your situation, but you do not possess sufficient information to answer them. In that instance, please select the option I DON'T KNOW where it is available.

Participant Consent

• I have read and understood the description of the above-mentioned project.

• I understand that my participation will involve an online questionnaire.

• I fully accept that by completing and submitting the questionnaire I am giving my consent to participate in this research study, and I understand and agree to the research conditions.

• I also understand and am satisfied with all the measures that will be taken to protect my identity and ensure my interests are protected.

• I agree to publication of results, with the understanding that my anonymity will be preserved.

There are 50 questions in this survey

General questions as to knowledge

1 Which country are you working in?
*****

Please choose **only one** of the following:

- ○ New Zealand
- ○ Australia
- ○ UK
- ○ Germany
- ○ Other [ ]

2 What forms of knowledge are important in your opinion?

Please choose **all** that apply:

- ☐ Intellectual capital (e.g. patents, technology licenses)
- ☐ Structural capital(e.g. production processes including financial and manufacturing)
- ☐ Human capital(e.g. human professional skills)

- [ ] CAD data for previous designs (e.g. design calculations)
- [ ] Data and information, fact sheets
- [ ] Design intent (functional intend/idea)
- [ ] Procedural knowledge (e.g. sequence of events, rules)
- [ ] Intuitive knowledge (e.g. design and decision-making)
- [ ] Other:

3 What is your company's knowledge based on?

Please choose **all** that apply:

- [ ] Literature
- [ ] Knowledge acquired during projects
- [ ] Individual knowledge of employees
- [ ] Don't know
- [ ] Other:

4 To what extent is your organization vulnerable to staff leaving and taking their knowledge with them?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

5 Which parts of the knowledge management process (capture – reuse – add value) do you use?

Please choose **all** that apply:

- [ ] Interviews with employees
- [ ] Regular meetings for knowledge exchange
- [ ] Creation of a database (e.g. intranet)
- [ ] Creation of presentations on project
- [ ] Work-shops
- [ ] Supporting a communicative work-climate
- [ ] Nothing
- [ ] Don't know
- [ ] Other:

6 How did your firm decide which knowledge management methods to use?

Please write your answer here:

7 To what extent is this knowledge management approach successful?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

8 If your organization does not fully use knowledge management practices, why is that?

Please choose **all** that apply:

- [ ] Don't know about the area.

- [ ] Do not perceive value in doing so.
- [ ] Too much effort and time (costs).
- [ ] People are too selfish.
- [ ] Culture does not encourage it.
- [ ] Don't know.
- [ ] Other:

9 To what extent does your organisation formally measure its intellectual capital?

Please choose **only one** of the following:

- ○ Almost always
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Almost never
- ○ Don't know or not applicable

Your practices

10 How easy is it for you to find and access stored knowledge?

Please choose **only one** of the following:

- ○ Very difficult to get results, even with effort. Frustrating experience.
- ○ Difficult, but achieveable with effort
- ○ Adequate ease of getting results
- ○ Easy to achieve results
- ○ Very easy, get results quickly and efficiently. Pleasant experience.
- ○ Don't know or Not applicable

11 What are the problems (if any) in your company regarding knowledge management as you see them?

Please write your answer here:

12 How often do you use knowledge management practices?

Please choose **only one** of the following:

- ○ Almost always
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Almost never
- ○ Don't know or not applicable

13 Which knowledge management practices (if any) do you personally find helpful in your job?

Please write your answer here:

14 How important is knowledge management for the successful completion of your job?

Please choose **only one** of the following:

- ○ Unimportant
- ○ Somewhat unimportant
- ○ Neutral
- ○ Somewhat important
- ○ Very important
- ○ Don't know or Not applicable

15 What do you think are the benefits of knowledge management for a company and the employees?

Please write your answer here:

16 To what extent does your firm use formal knowledge-capture processes? (For example Observation & documentation of work practices; structured analysis of the cognitive tasks performed by staff).

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

Personal sharing of knowledge

17 What does your firm do to encourage people to share their knowledge?

Please choose **all** that apply:

- ☐ Regular meetings for knowledge exchange
- ☐ Supporting a communicative work-climate
- ☐ Encouraging employees to present knowledge/ideas
- ☐ Recognition for sharing knowledge
- ☐ Nothing
- ☐ Don't know
- ☐ Other: _____

18 How would you rate your willingness to share knowledge within the company?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

19 What factors make it difficult for you to share your knowledge?

Please choose **all** that apply:

- ☐ Workgroup competition
- ☐ Personal goals (promotion)
- ☐ Poor work-climate
- ☐ Antipathy regarding particular co-workers
- ☐ No financial incentive
- ☐ Lack of time to share knowledge
- ☐ Need to preserve position
- ☐ No personal benefits
- ☐ They have not reciprocated when I've helped them before
- ☐ Don't know
- ☐ Confidentiality of knowledge
- ☐ Other: _____

20 What factors generally increase (or would increase) your motivation to share knowledge?

Please write your answer here:

21 How would you rate your willingness to ask questions in order to acquire knowledge?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

22 How would you rate the willingness of your co-workers to share knowledge within the company?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent

- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

23 What could be reasons for you to seek knowledge from others?

Please choose **all** that apply:

- ☐ Good relationship to co-workers
- ☐ Communicative work-climate
- ☐ Pressure to succeed (e.g. regarding a project)
- ☐ Regular meetings
- ☐ Personal interest
- ☐ Willingness to improve own knowledge
- ☐ Social aspects (e.g. sense of team work)
- ☐ Don't know
- ☐ Other: [ ]

24 What would keep you from seeking knowledge from others?

Please choose **all** that apply:

- ☐ Poor relationship with co-worker
- ☐ Avoid appearing ignorant
- ☐ Do not need their information
- ☐ No reason or motivatation to do so
- ☐ Don't know
- ☐ Other: [ ]

25 To what extent would you consider yourself an extraverted person?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

Extraversion is characterized by positive emotions, surgency, and the tendency to seek out stimulation and the company of others. In groups they like to talk, assert themselves, and draw attention to themselves.(wikipedia)

26 To what extent would you consider yourself an 'open' person?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

Openness is a general appreciation for art, emotion, adventure, unusual ideas, imagination, curiosity, and variety of experience. The trait distinguishes imaginative people from down-to-earth, conventional people. People who are open to experience are intellectually curious, appreciative of art, and sensitive to beauty. They tend to be, compared to closed people, more creative and more aware of their feelings. They are more likely to hold unconventional beliefs. (wikipedia)

27 To what extent do the Human resource management incentives (e.g. internal competition between units, performance based pay, appraisals, management-by-objectives) suppresses knowledge sharing?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

28 Where there is a willingness to share knowledge, is it stronger within a workgroup than in the wider organisation?

Please choose **only one** of the following:

- ○ Definitely Yes

- ○ Cautiously Yes
- ○ Maybe
- ○ Probably Not
- ○ Definitely Not
- ○ Don't know or Not applicable

Organisational relationships

29 To what extent does the kind of relationship you have to your co-workers influence your willingness to share knowledge or ask them to do so?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

30 To what extent does trust influence your willingness to share and ask for knowledge?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

31 How would you rate the general climate (organisational culture) in your company?

Please choose **only one** of the following:

- ○ Bad
- ○ Poor
- ○ Adequate
- ○ Good
- ○ Excellent
- ○ Don't know or Not applicable

32 How important is the following for you regarding your job?

Please choose the appropriate response for each item:

	1	2	3	4	5
Job security	○	○	○	○	○
Salary	○	○	○	○	○
Working hours	○	○	○	○	○
Work-life balance	○	○	○	○	○
Chance for promotion	○	○	○	○	○
Work climate	○	○	○	○	○
Challenging tasks	○	○	○	○	○
Reputation of the company	○	○	○	○	○
Location of the company	○	○	○	○	○
Chance to work overseas	○	○	○	○	○

Scale from 1 to 5, where 5 is very important.

33 Which of the following roles are you most comfortable performing in a project team?

Please choose **only one** of the following:

- ○ Leader
- ○ Team-player
- ○ Specialist contribution
- ○ Other

Make a comment on your choice here:

34 In a project or within the organisation, to what extent do you contribute to setting direction?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

35 How easy do you find it to seek knowledge from

Please choose the appropriate response for each item:

	1	2	3	4	5
Superiors	○	○	○	○	○
Subordinate	○	○	○	○	○
Peer	○	○	○	○	○

Scale from 1 to 5, where 5 is the easiest. Please rate each of the following.

New Product Development

36 At what stage during NPD does your company tend to use KM methods?

Please choose **all** that apply:

- ☐ Concept design
- ☐ Detailed design
- ☐ Embodiment
- ☐ Production
- ☐ Do not use it
- ☐ Don't know
- ☐ Other:

NPD is new product development

37 To what extent are you personally involved with NPD? *

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

38 To what extent is your company involved with new product development (NPD)? *

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

39 What are the problems as you see them regarding NPD projects?

Please write your answer here:

These could be difficulties in general or specific constraints within your organisation.

40 Do you have any suggestions on how these problems might be solved? (Either in general or your organisational specifically).

Please write your answer here:

41 In your experience, is knowledge really important for innovation?

Please choose **only one** of the following:

- ○ Definitely Yes
- ○ Cautiously Yes
- ○ Maybe

- ○ Probably Not
- ○ Definitely Not
- ○ Don't know or Not applicable

42 To what extent is knowledge in your opinion a competitive advantage over other companies?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

43 To what extent does increased knowledge automatically result in innovation?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent
- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

44 What would improve the sharing of knowledge in your organization?

Please write your answer here:

Demographics

45 What type of organizational structure do you work in?

Please choose **all** that apply:

- ☐ Departments
- ☐ Project teams
- ☐ Matrix
- ☐ Cross-functional
- ☐ Other: _____

46 How many people work for your organization (approximately)? *

Please write your answer here:

_____

47 What is your gender?

Please choose **only one** of the following:

- ○ Female
- ○ Male

48 What is your age?

Please write your answer here:

_____

49 What is your role?

Please choose **all** that apply:

- ☐ Designer
- ☐ Quality engineer
- ☐ Team leader
- ☐ Manager
- ☐ Other: _____

50 What is your qualification?

Please choose **all** that apply:

- ☐ Bachelors degree
- ☐ Masters degree
- ☐ PhD
- ☐ Trade
- ☐ Other: _____

Thank you very much for participating in this survey. Your responses are very important to our research project.

We greatly appreciate your time and feedback.

If you are interested in keeping in touch with us and being informed about the results of this and further studies you can leave your contact details with us. We would be happy to provide you with the results.

Please click on the following link, which will lead you to a contact detail form. This is a separate database and is not linked to your responses to the main survey. The same privacy conditions apply.

All your answers from the questionnaire can **NOT** be referred to your contact details.
Please note, that all your answers are anonymous and confidential.

Also if you have any questions or comments, please do not hesitate to contact us. Volker Wochele: volker.wochele@pg.canterbury.ac.nz or Dirk Pons: dirk.pons@canterbury.ac.nz

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UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Submit your survey.
Thank you for completing this survey.

APPENDIX B: KM INTERVIEW QUESTIONS

UC: Knowledge management interview

This survey has been reviewed and approved by the Department of Mechanical Engineering, University of Canterbury. If you have any questions or concerns about this research, please contact the supervisor Dr. Dirk Pons (dirk.pons@canterbury.ac.nz).
The introduction and consent for this survey is shown here:
http://tiro.co.nz/survey/index.php?sid=47757&newtest=Y&lang=en
By participating in this survey you agree to the conditions therein.

There are 9 questions in this survey

Demographics

1

Participant Consent

• I have read and understood the description of the above-mentioned project.

• I understand that my participation will involve a face-to-face interview. I understand that I can withdraw from the interview at any time.

• I fully accept that by completing the interview I am giving my consent to participate in this research study, and I understand and agree to the research conditions.

• I also understand and am satisfied with all the measures that will be taken to protect my identity and ensure my interests are protected.

• I agree to publication of results, with the understanding that my anonymity will be preserved. *

Please choose **only one** of the following:

- ○ Yes
- ○ No

Interview questions

2 Do you think communication within a company (organization) is important?

Please choose **only one** of the following:

- ○ Definitely Yes
- ○ Cautiously Yes
- ○ Maybe
- ○ Probably Not
- ○ Definitely Not
- ○ Don't know or Not applicable

3 What do you understand by 'communication'?

Please write your answer here:

4 Have you heard of 'knowledge management' before?

Please choose **only one** of the following:

- ○ Definitely Yes
- ○ Cautiously Yes
- ○ Maybe
- ○ Probably Not
- ○ Definitely Not
- ○ Don't know or Not applicable

(Researcher will explain as necessary).

5 How important do you think knowledge management is for your business (organization)?

Please choose **only one** of the following:

- ○ Not at all
- ○ Small extent

- ○ Moderate extent
- ○ Great extent
- ○ Very great extent
- ○ Don't know or not applicable

6 Which knowledge management strategy do you prefer, codification or personalization? Please explain.

Please write your answer here:

(The Researcher will explain codification or personalization as necessary).

7 In your opinion, which of these strategies is used in your company? How is it applied?

Please write your answer here:

8 What could be done to improve the current knowledge management process?

Please write your answer here:

9 To what extent are you personally involved in new product development? Can you give some examples?

Please write your answer here:

Submit your survey.
Thank you for completing this survey.

Appendix C:
Detailed Survey Analysis

The purpose of this particular document is to show the analysis, the charts and graphs for each survey question. In order to do that the original structure of the survey was laid out using the different survey question groups. Based on this analysis interesting results can be found easily and used for the main body of the Masters thesis eventually.

Contents

1 Method of analysis

The minimum levels of SAL (sequence, association and link analysis) support and confidence were generally set at 10% support and 10% confidence for this study, except where otherwise shown. These levels are slightly low, but are appropriate for the relatively small data-set considered here.

2 General questions as to knowledge

2.1 Which countries do the participants work in?

Most survey respondents work in New Zealand. But there is also a rather high percentage of participants from Germany. That is why the results of these two countries were compared.

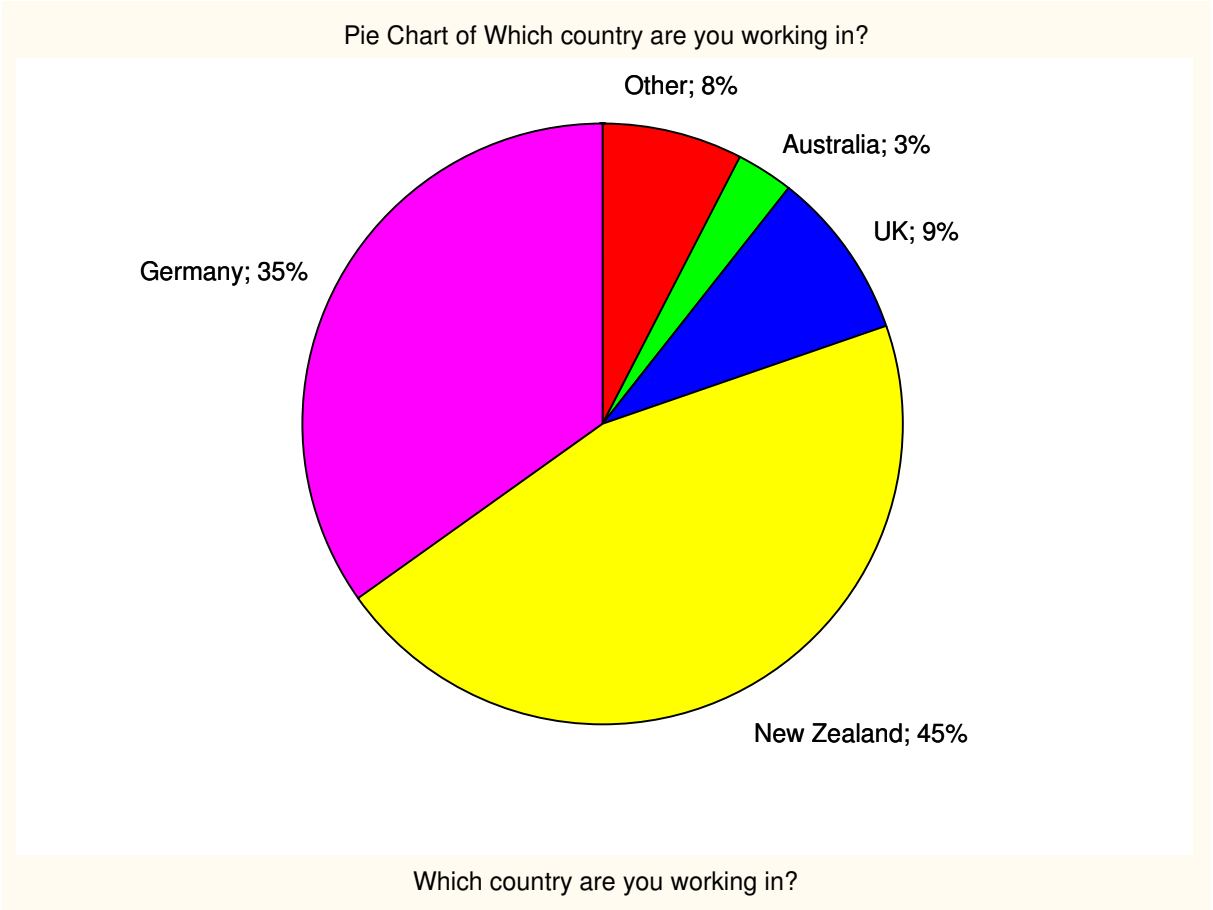


Figure 1

2.2 What forms of knowledge are important in your opinion?

Figure 2 shows that human capital is considered the most important form of knowledge, however, intellectual capital and structural capital are almost as important in the opinion of the survey respondents.

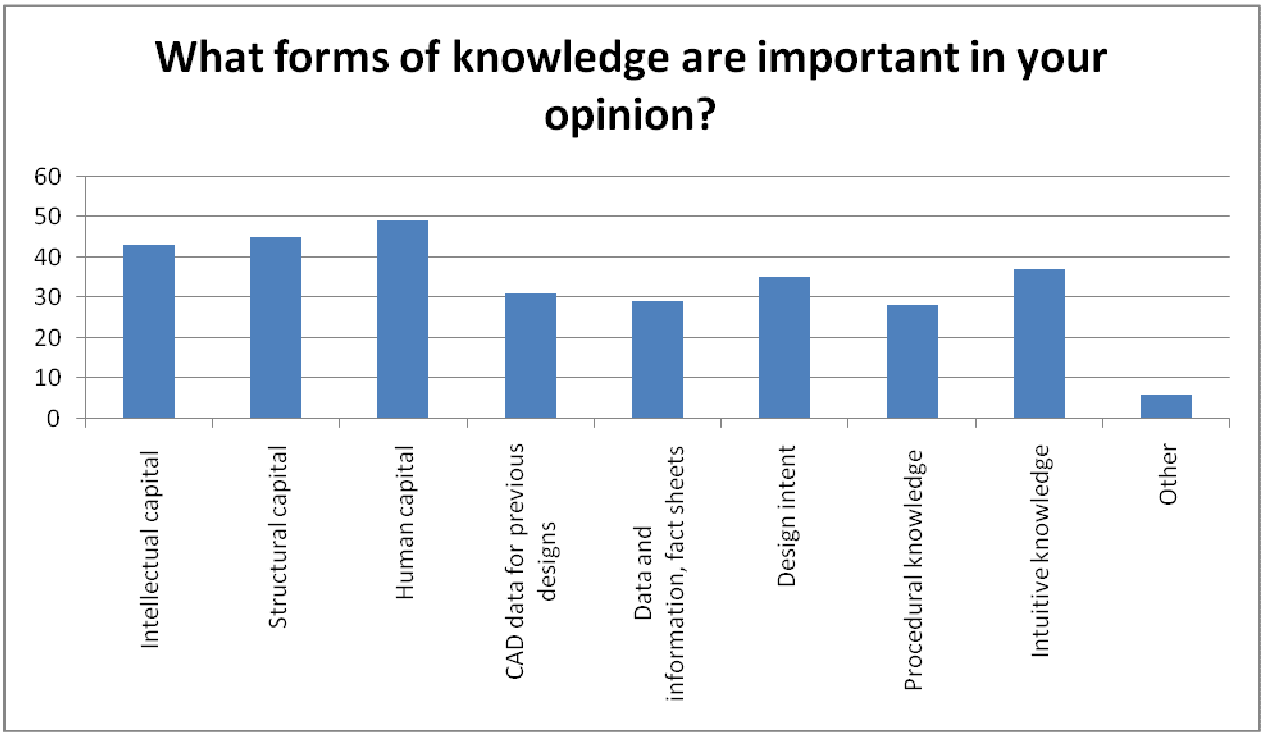


Figure 2

2.2.1 Comparison between New Zealand and Germany

While intellectual capital and structural are considered equally important in both countries, there are some differences regarding other forms of knowledge. Smaller variations can be due to the higher number of survey respondents from New Zealand. However, there is not statistically significant difference between both countries. Results that seemed to differentiate more, were analysed through ANOVA to explore the statistical significance.

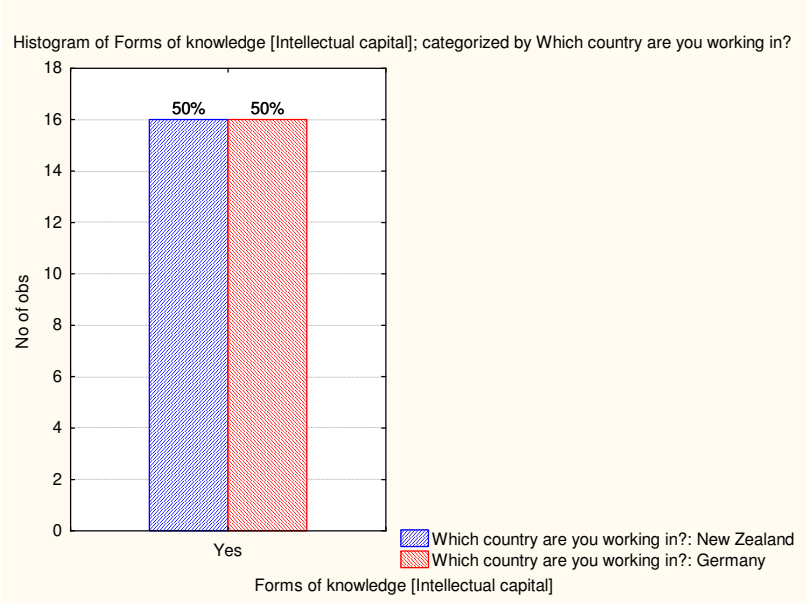


Figure 3

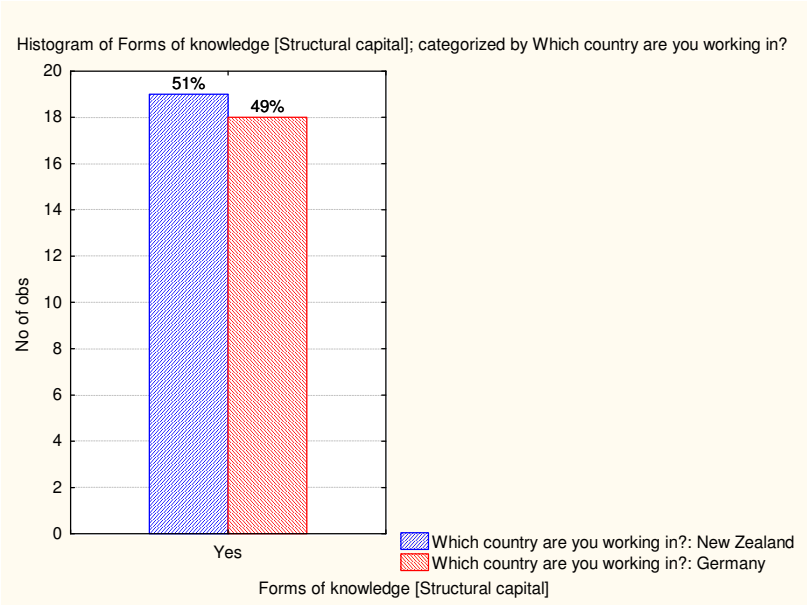


Figure 4

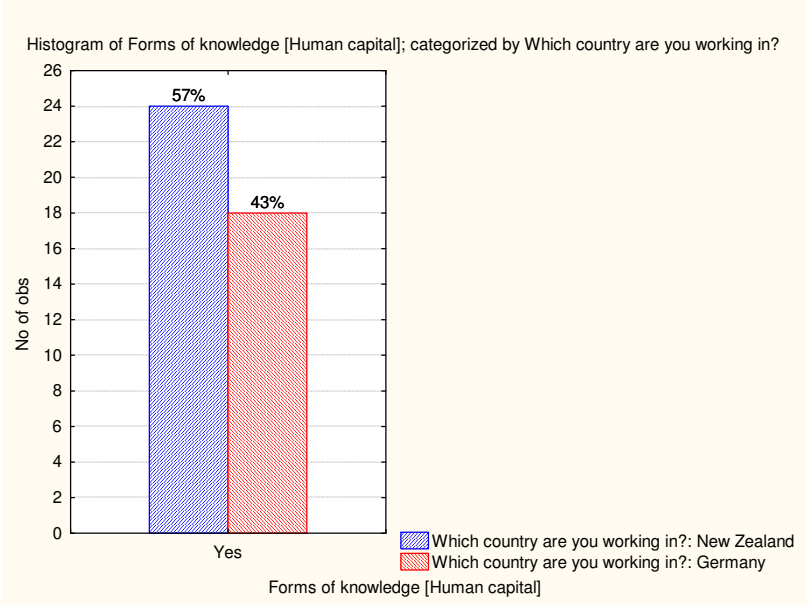


Figure 5

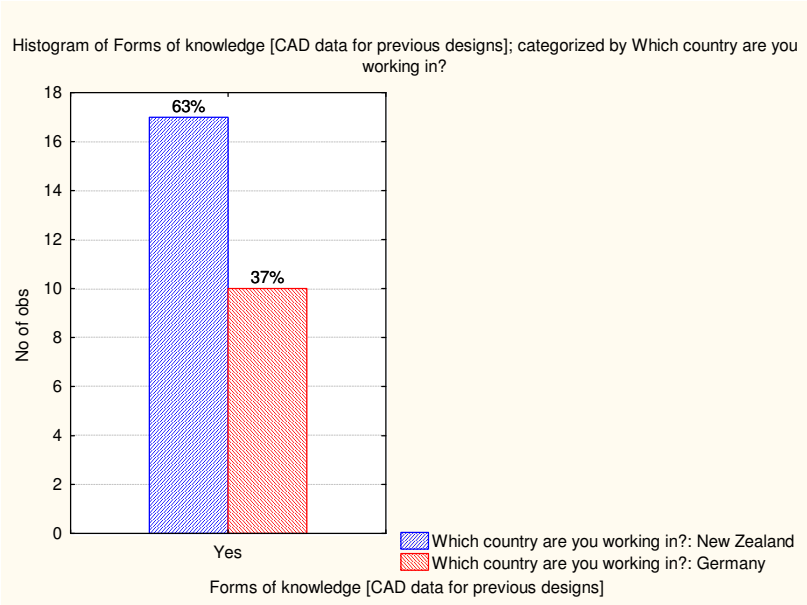


Figure 6

The difference seen in *Figure 6* is not statistically significant. This can be seen in *Figure 7 (p=0.35).*

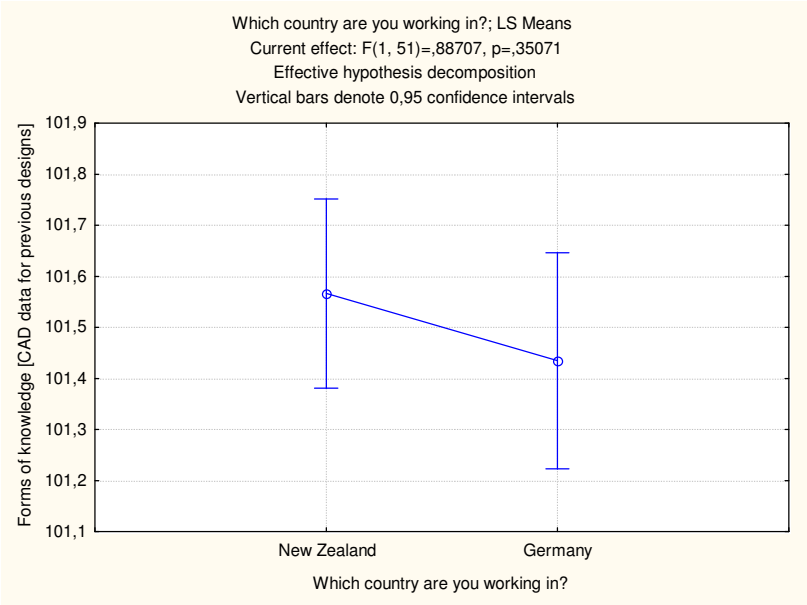


Figure 7

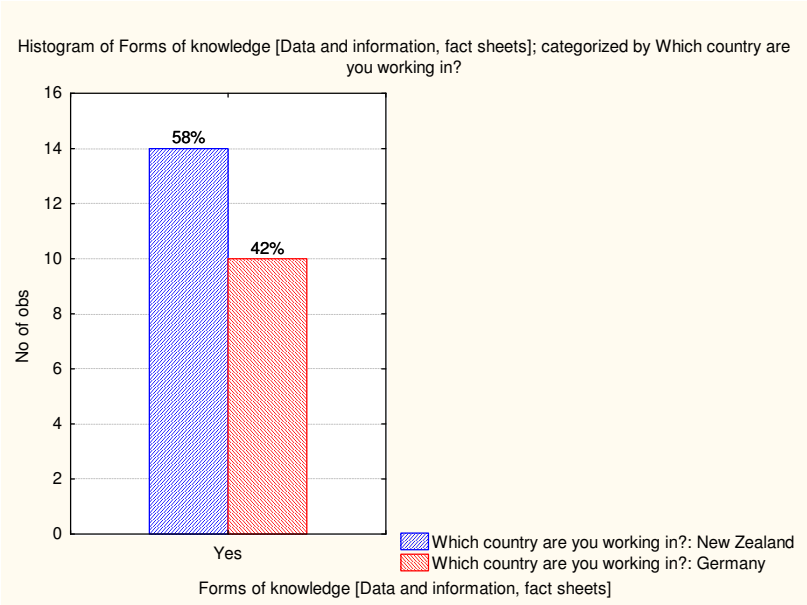


Figure 8

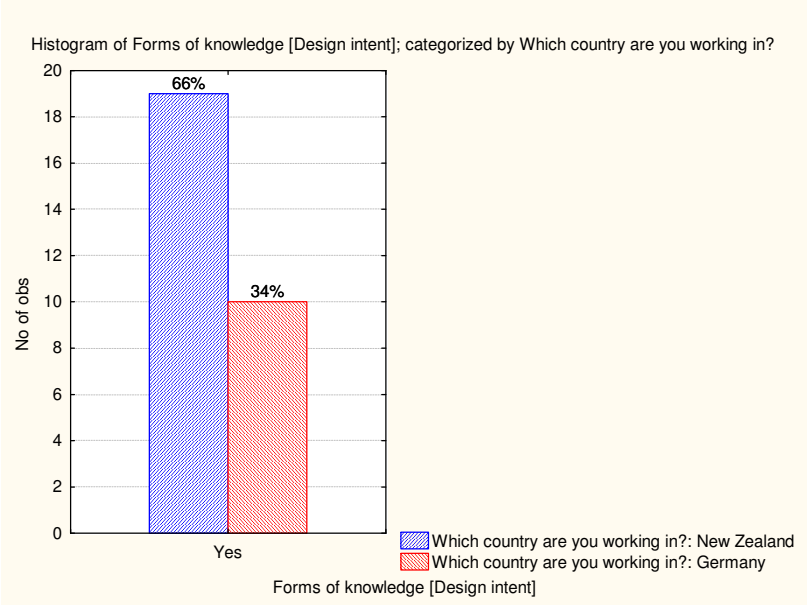


Figure 9

The difference seen in *Figure 9* is not statistically significant. This can be seen in *Figure 10 (p=0.16).*

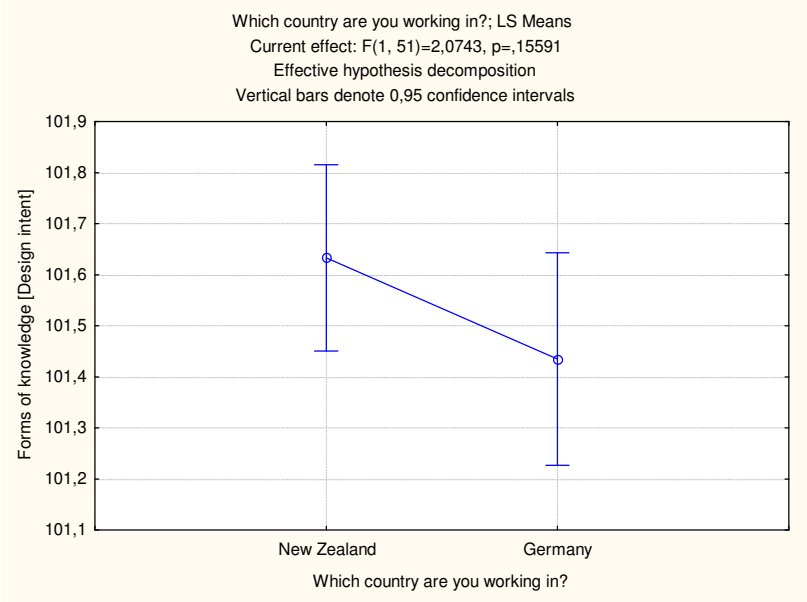


Figure 10

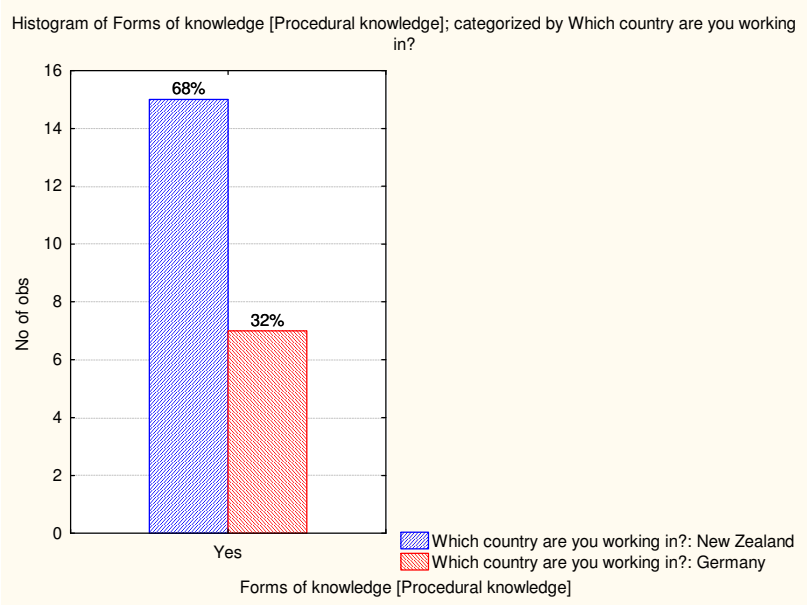


Figure 11

The difference seen in *Figure 11* is not statistically significant. This can be seen in *Figure 12 (p=0.16).*

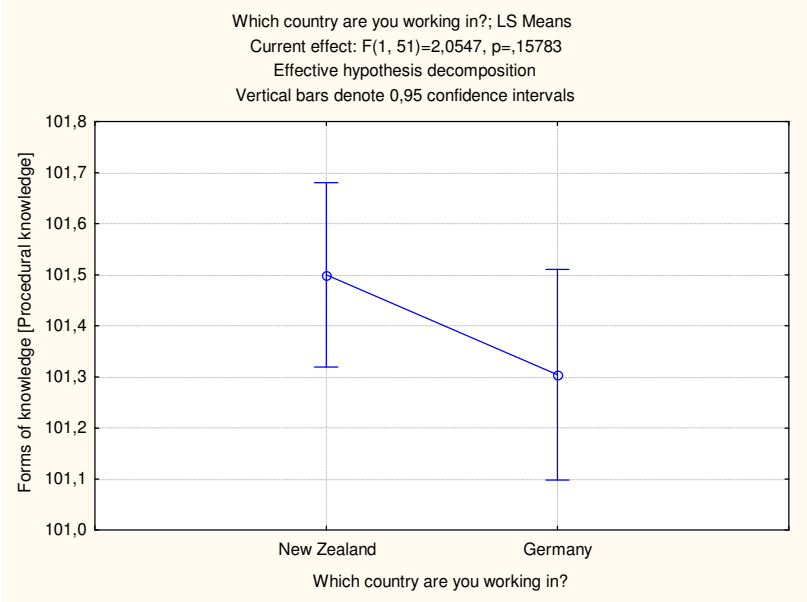


Figure 12

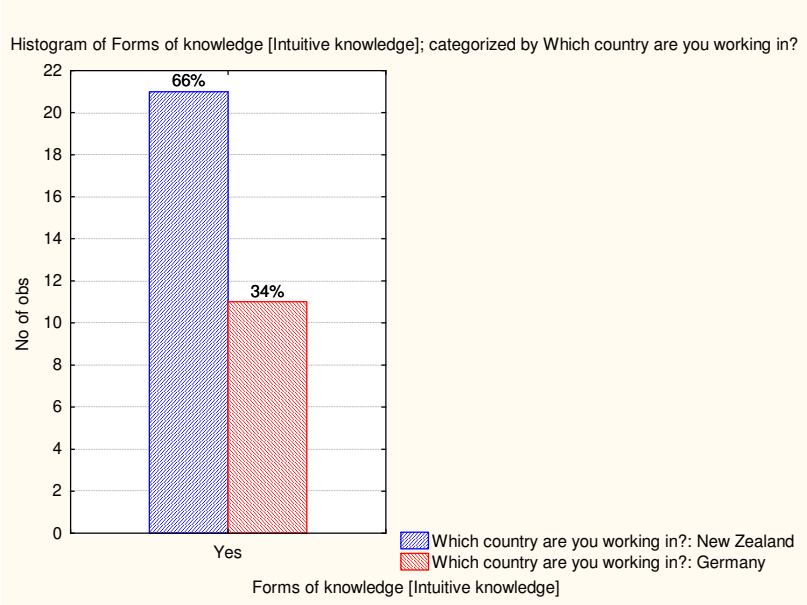


Figure 13

The difference seen in *Figure 13* is not statistically significant. This can be seen in *Figure 14 (p=0.11).*

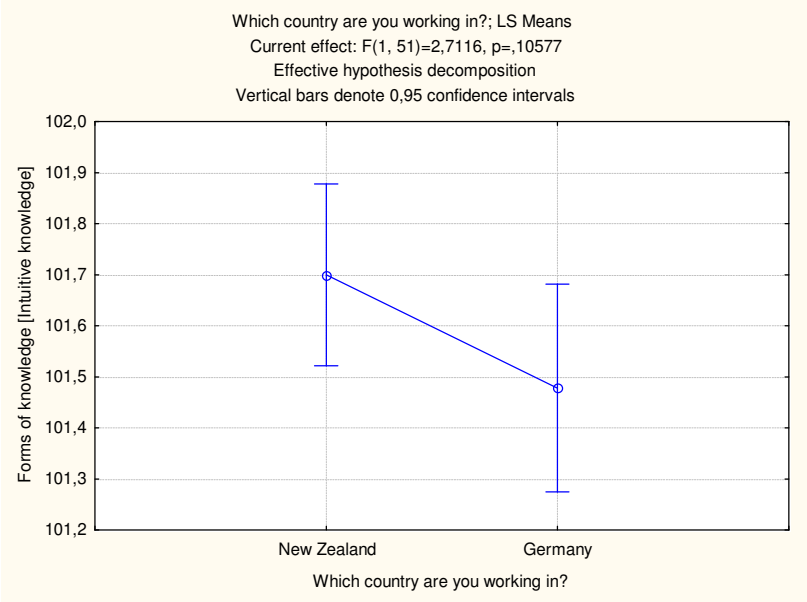


Figure 14

2.3 What is your company's knowledge based on?

Figure 15 shows that the knowledge of most companies is mainly based on knowledge that was acquired during previous projects and the knowledge of individuals. The points out even stronger how important it is to use sophisticated knowledge management practices in order to be able to capitalize from these particular forms of knowledge.

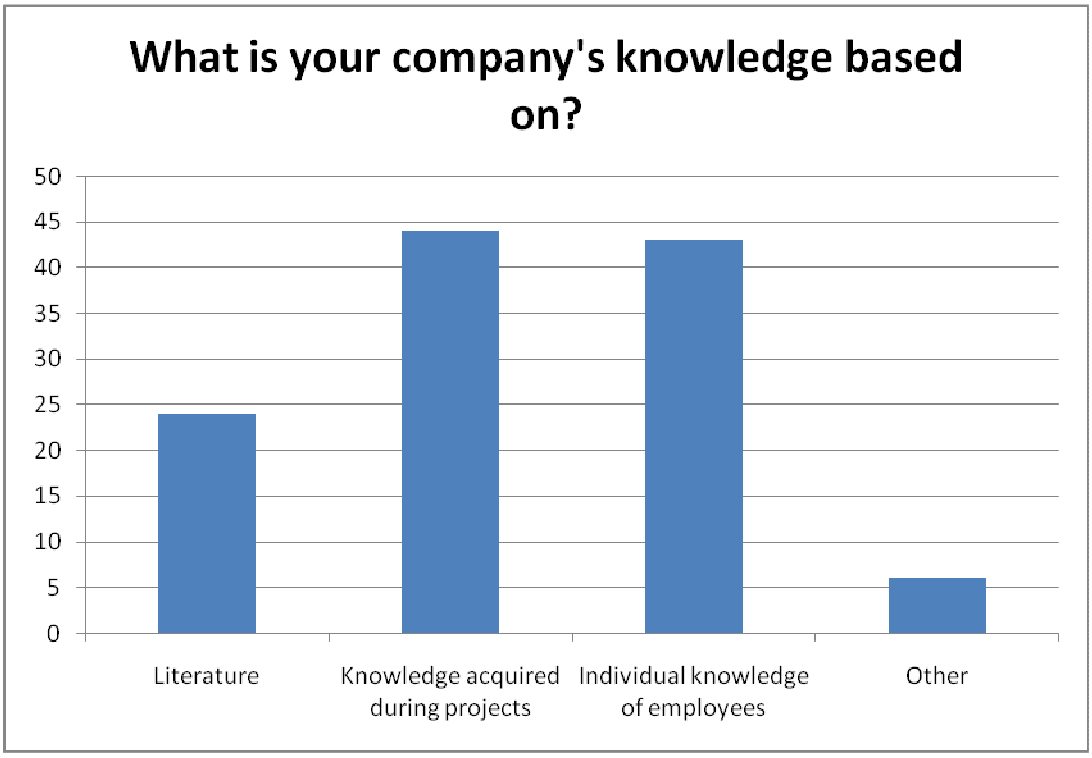


Figure 15

2.3.1 Comparison between New Zealand and Germany

It is very interesting to see that companies in New Zealand tend to base their knowledge more on literature than companies in Germany. Knowledge that was acquired during projects and individual knowledge are found to be equally influential. The differences that were found regarding literature are statistically significant (see *Figure* 17, ANOVA p=0.04).

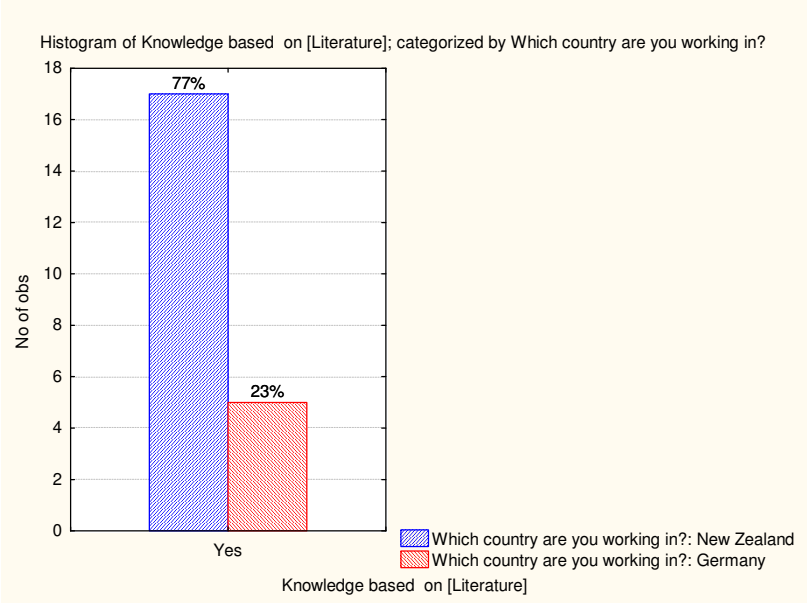


Figure 16

Companies in New Zealand seem to base their knowledge stronger on literature than companies in Germany. ANOVA showed that the difference shown in *Figure 16* is statistically significant (p=0.04).

Figure 17

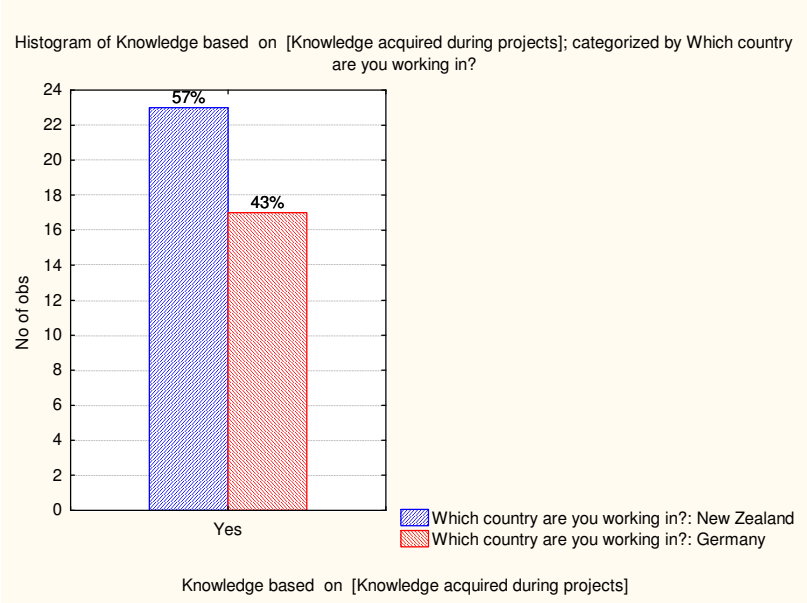


Figure 18

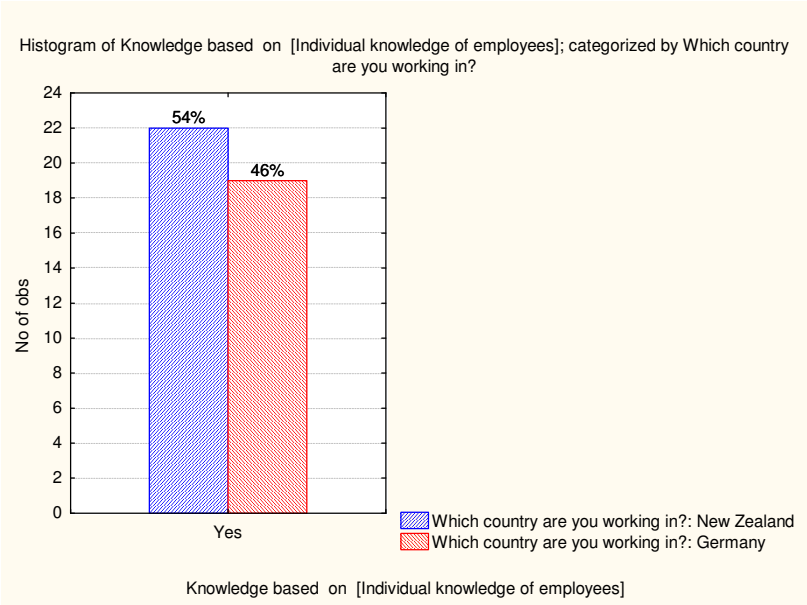


Figure 19

2.4 To what extent is your organization vulnerable to staff leaving and taking their knowledge with them?

Figure 20 shows that most companies are moderately vulnerable to staff leaving and taking their knowledge with them. But on the whole there is a tendency towards higher, rather than lower vulnerability.

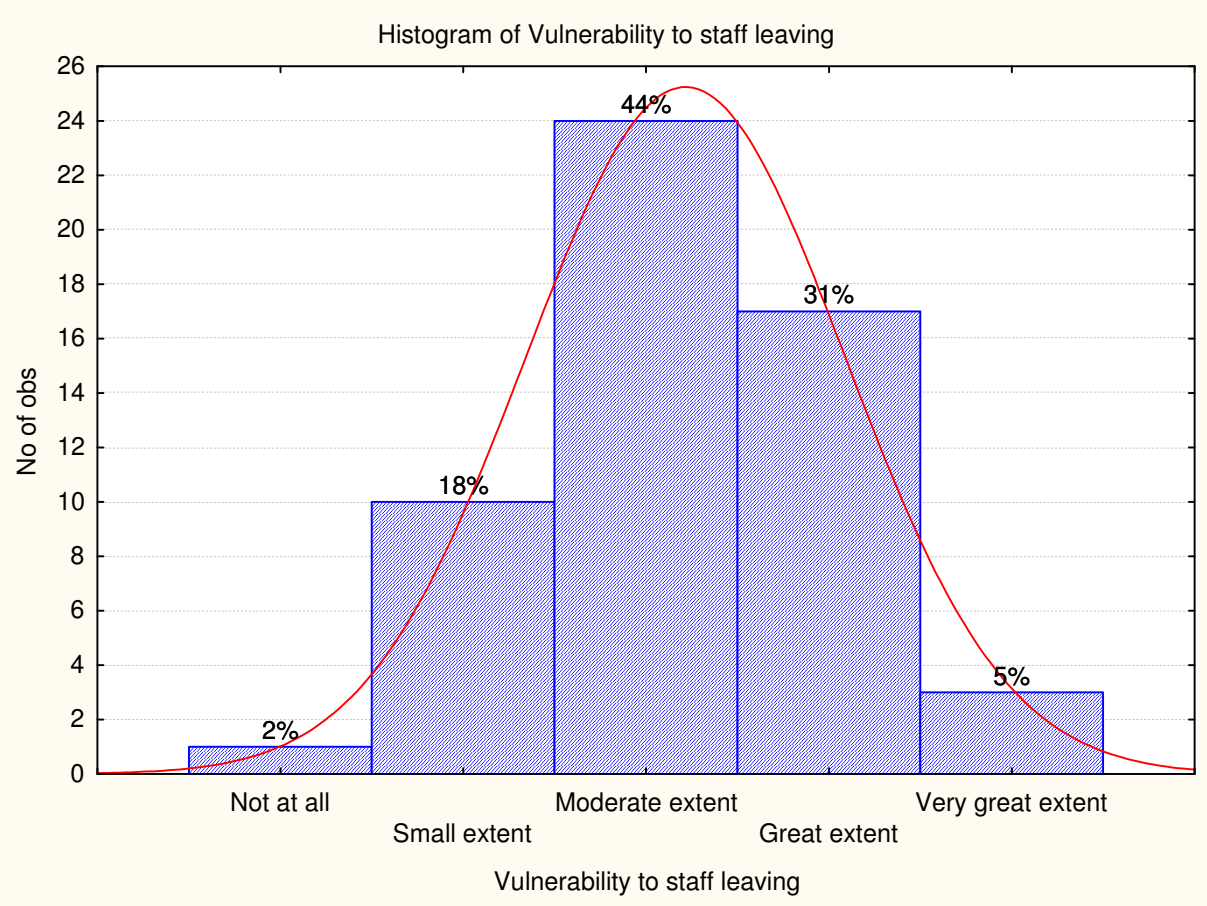


Figure 20

2.4.1 Comparison between New Zealand and Germany

Some respondents found that their company was vulnerable to a very great extent, and a tendency towards a more negative perception can be assumed (see *Figure 21*). But ANOVA (see *Figure 22*) shows that the differences are not statistically significant (p=0.74).

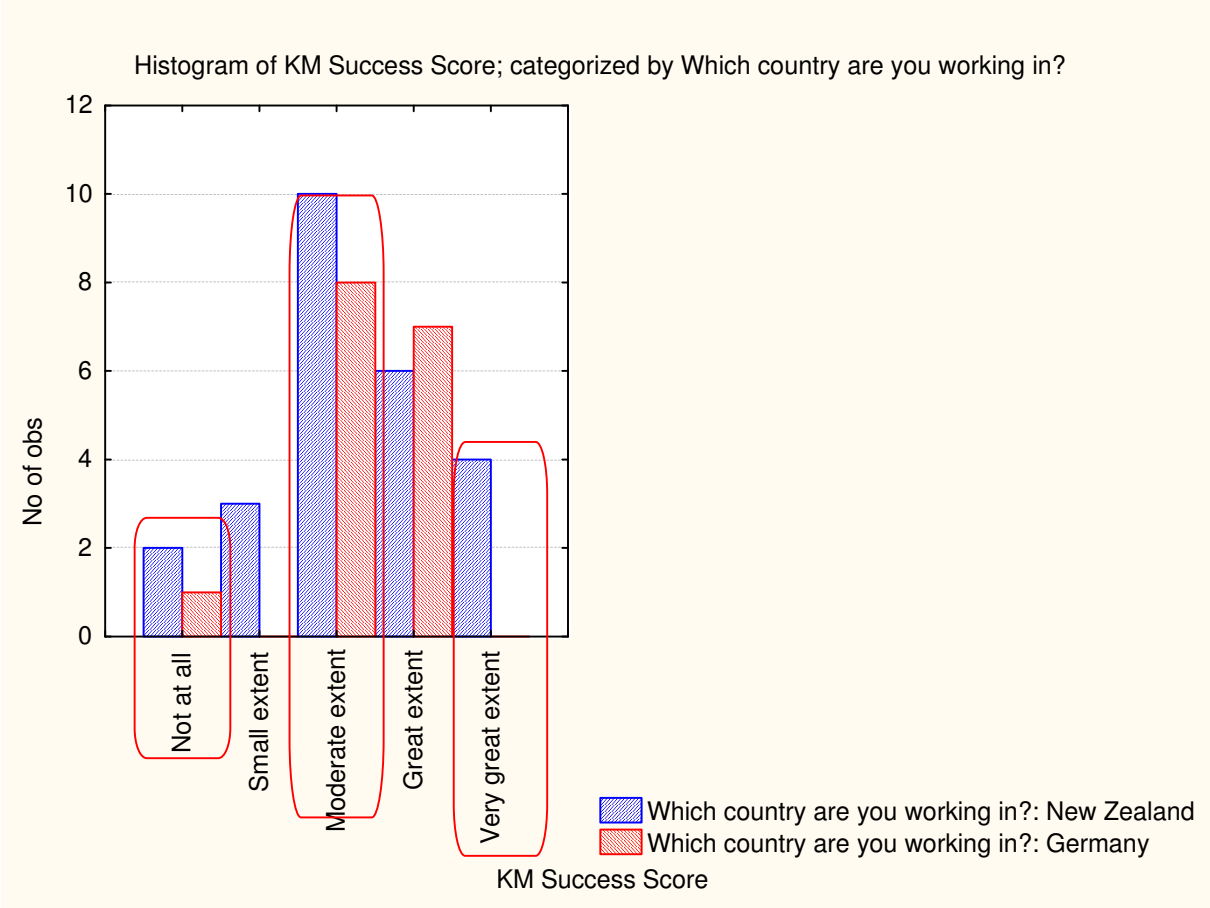


Figure 21

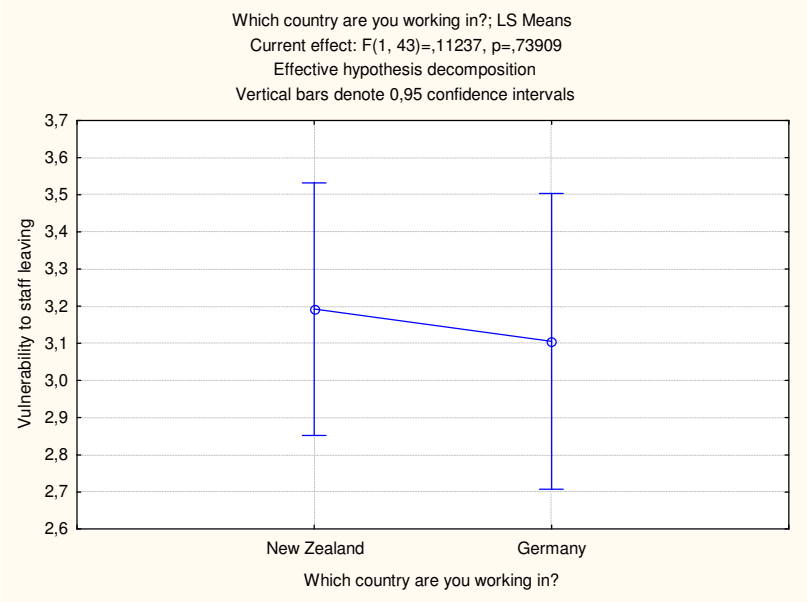


Figure 22

2.4.2 Association with KM Success

The SAL shows (see *Figure 23*) a particular association between organisations with a moderate to great KM success being moderately vulnerable to staff leaving: (95% of organisations with a moderate to great KM success were moderately vulnerable to staff leaving).

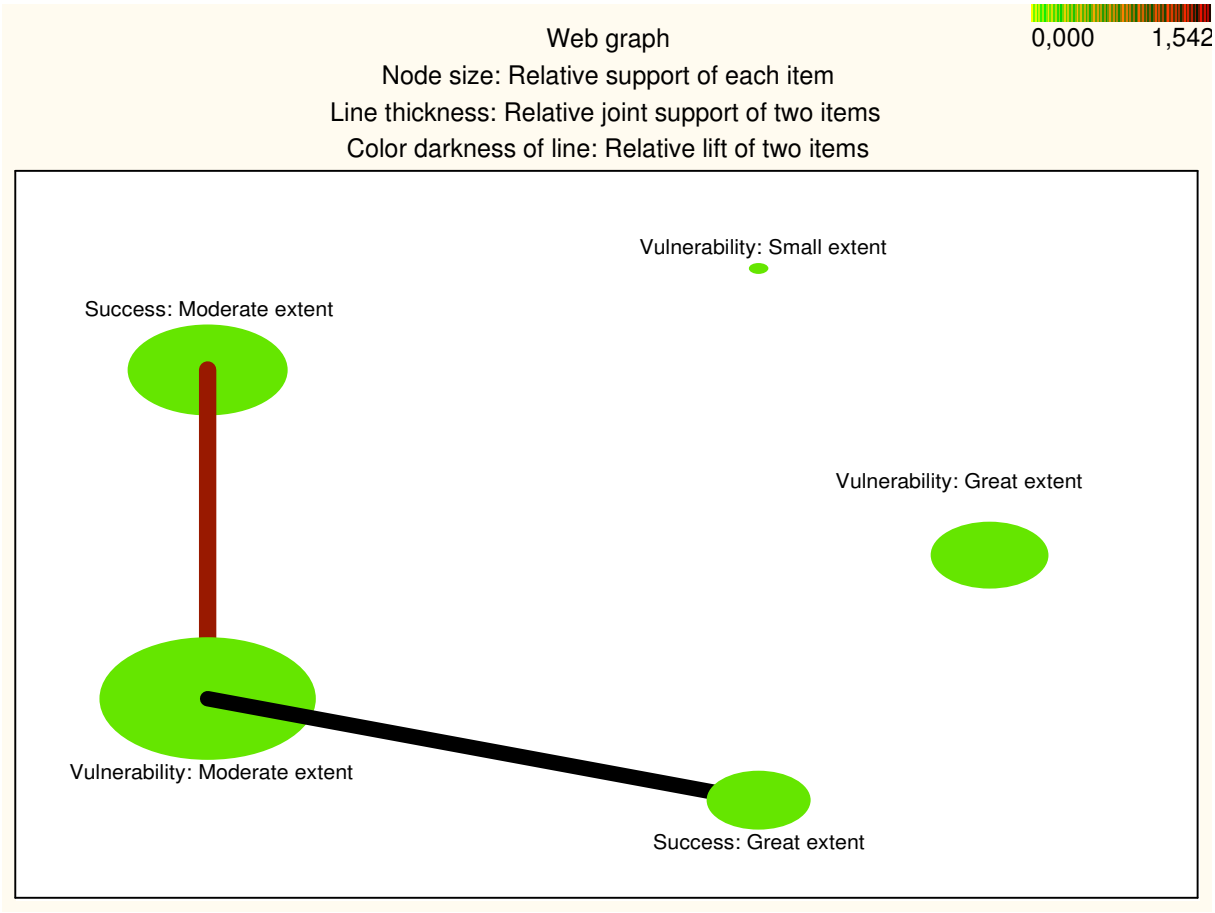


Figure 23: SAL for vulnerability to staff leaving and KM success, min. support 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.04.stw) Min: support = 10.0%, confidence = 10.0%
Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Vulnerability to staff leaving==Moderate extent	==>	KM Success Score==Moderate extent	12.16216	37.50000	1.387500
2	KM Success Score==Moderate extent	==>	Vulnerability to staff leaving==Moderate extent	12.16216	45.00000	1.387500
3	KM Success Score==Great extent	==>	Vulnerability to staff leaving==Moderate extent	10.81081	50.00000	1.541667
4	Vulnerability to staff leaving==Moderate extent	==>	KM Success Score==Great extent	10.81081	33.33333	1.541667

Figure 24

2.4.3 Association with particular KM processes

Through SAL it showed that companies with a moderate vulnerability to staff leaving are associated with the creation of a database and supporting a communicative work climate. The analysis did not find an association between a low vulnerability and particular knowledge management processes. However it did show the association *between* the different methods. For example, a communicative culture was associated with having a database, meetings and presentations (but not particularly with workshops or interviews).

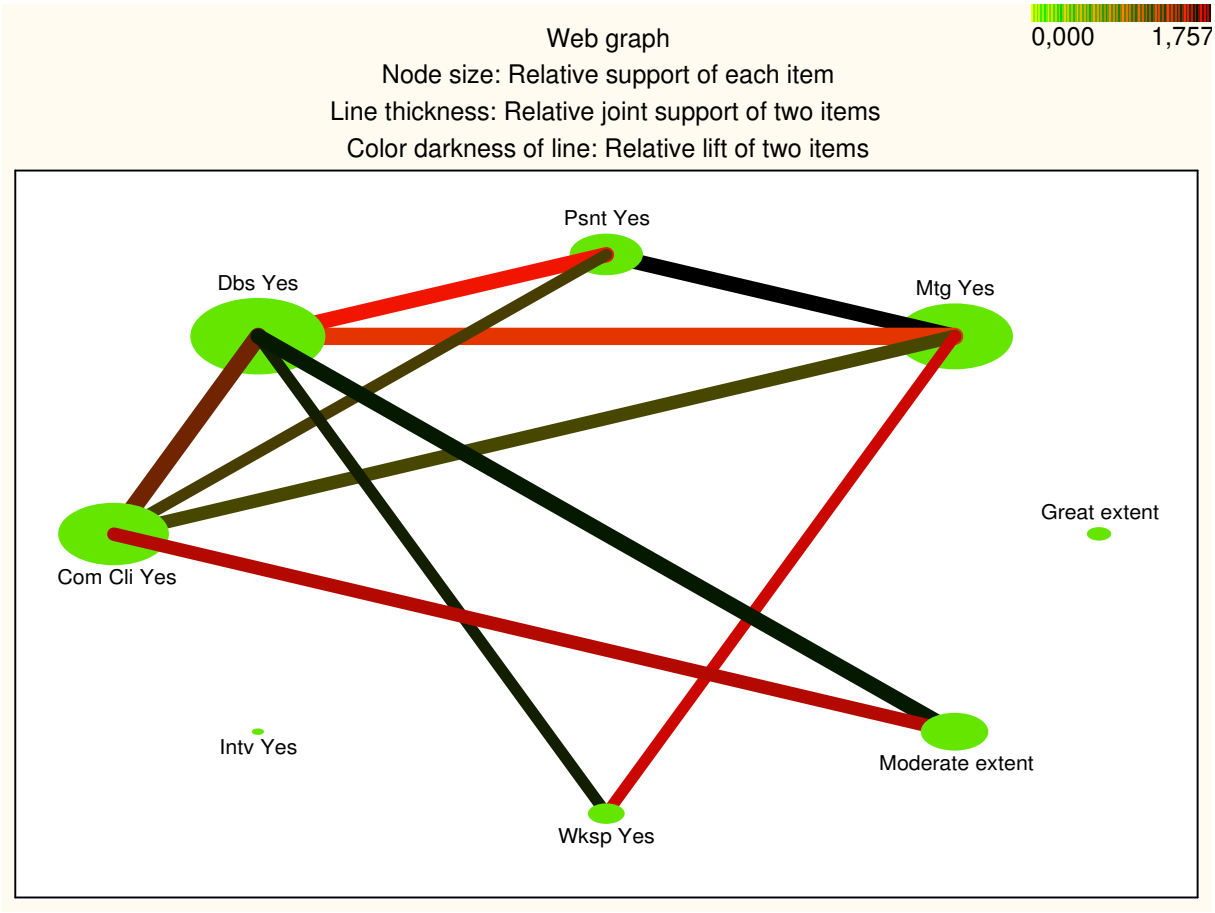


Figure 25: SAL for vulnerability to staff leaving and particular KM processes, min support 0.2, confidence 0.15

Summary of association rules (University of Canterbury Resear in Workbook_1.08.stw) Min: support = 20,0%, confidence = 15,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Wksp Yes	==>	Mtg Yes	18,91892	73,6842	1,703947
2	Mtg Yes	==>	Wksp Yes	18,91892	43,7500	1,703947
3	Com Cli Yes	==>	Mtg Yes	22,97297	54,8387	1,268145
4	Mtg Yes	==>	Com Cli Yes	22,97297	53,1250	1,268145
5	Dbs Yes	==>	Mtg Yes	28,37838	60,0000	1,387500
6	Mtg Yes	==>	Dbs Yes	28,37838	65,6250	1,387500
7	Dbs Yes	==>	Mtg Yes, Psnt Yes	22,97297	48,5714	1,891729

8	Psnt Yes	==>	Mtg Yes, Dbs Yes	22,97297	68,0000	2,396190
9	Psnt Yes, Dbs Yes	==>	Mtg Yes	22,97297	89,4737	2,069079
10	Mtg Yes	==>	Psnt Yes, Dbs Yes	22,97297	53,1250	2,069079
11	Mtg Yes, Dbs Yes	==>	Psnt Yes	22,97297	80,9524	2,396190
12	Mtg Yes, Psnt Yes	==>	Dbs Yes	22,97297	89,4737	1,891729
13	Psnt Yes	==>	Mtg Yes	25,67568	76,0000	1,757500
14	Mtg Yes	==>	Psnt Yes	25,67568	59,3750	1,757500
15	Com Cli Yes	==>	Psnt Yes	18,91892	45,1613	1,336774
16	Psnt Yes	==>	Com Cli Yes	18,91892	56,0000	1,336774
17	Com Cli Yes	==>	Psnt Yes, Dbs Yes	18,91892	45,1613	1,758913
18	Dbs Yes	==>	Psnt Yes, Com Cli Yes	18,91892	40,0000	2,114286
19	Dbs Yes, Com Cli Yes	==>	Psnt Yes	18,91892	63,6364	1,883636
20	Psnt Yes	==>	Dbs Yes, Com Cli Yes	18,91892	56,0000	1,883636
21	Psnt Yes, Com Cli Yes	==>	Dbs Yes	18,91892	100,0000	2,114286
22	Psnt Yes, Dbs Yes	==>	Com Cli Yes	18,91892	73,6842	1,758913
23	Dbs Yes	==>	Psnt Yes	25,67568	54,2857	1,606857
24	Psnt Yes	==>	Dbs Yes	25,67568	76,0000	1,606857
25	Moderate extent	==>	Dbs Yes	24,32432	75,0000	1,585714
26	Dbs Yes	==>	Moderate extent	24,32432	51,4286	1,585714
27	Wksp Yes	==>	Dbs Yes	18,91892	73,6842	1,557895
28	Dbs Yes	==>	Wksp Yes	18,91892	40,0000	1,557895
29	Com Cli Yes	==>	Dbs Yes	29,72973	70,9677	1,500461
30	Dbs Yes	==>	Com Cli Yes	29,72973	62,8571	1,500461
31	Moderate extent	==>	Com Cli Yes	22,97297	70,8333	1,690860
32	Com Cli Yes	==>	Moderate extent	22,97297	54,8387	1,690860

Figure 26

2.4.4 Association with accessibility of knowledge

As shown in *Figure 27* an association between a moderate vulnerability to staff leaving the company and difficulties regarding finding stored knowledge can be found.

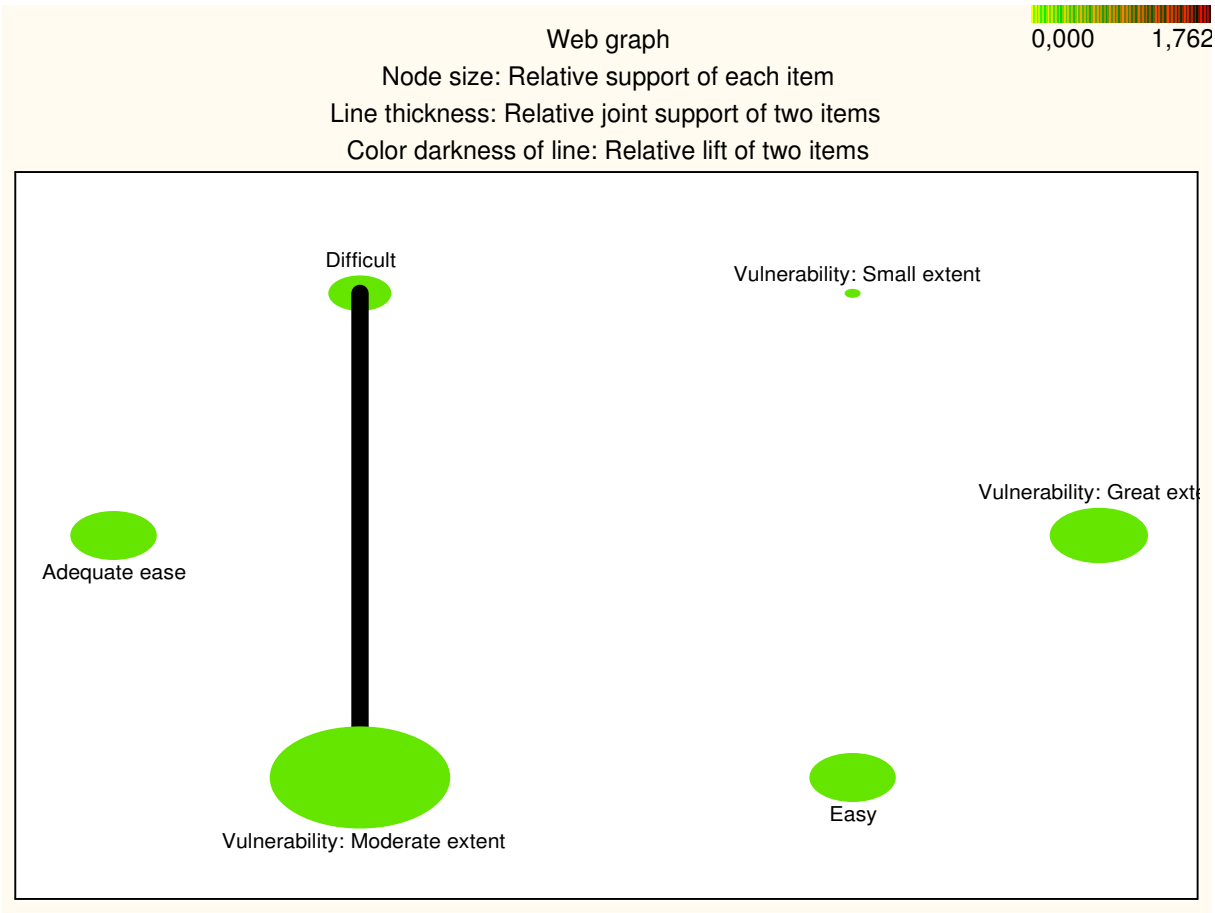


Figure 27: SAL for vulnerability to staff leaving and accessiblity of knowledge, min support 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.09.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10						
	Body	**==>**	**Head**	**Support(%)**	**Confidence(%)**	**Lift**
1	Vulnerability: Moderate extent	==>	Difficult	10,81081	33,33333	1,761905
2	Difficult	==>	Vulnerability: Moderate extent	10,81081	57,14286	1,761905

Figure 28

2.5 Which parts of the KM process do you use?

The most common KM practices that are used in NPD companies are regular meetings, the creation of a database and supporting a communicative work-climate, see *Figure 29.*

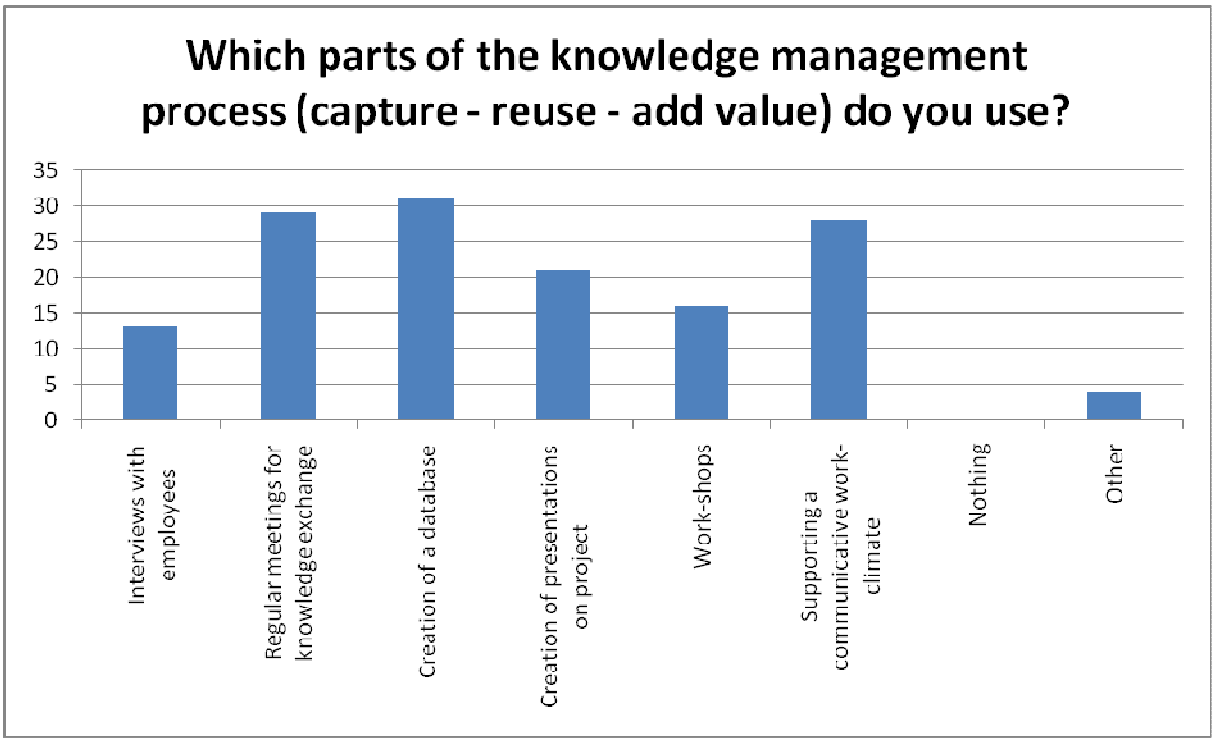


Figure 29

2.5.1 Comparison between New Zealand and Germany

The reults in *Figure 30-37* show that the practices in New Zealand and Germany are rather similar. However, work-shops and interviews with employees are more common in German organisations while a communicative work-climate is supported more in New Zealand. Only the difference regarding workshops was proved statistically significant through ANOVA (p=0,03).The results for interviews with employees were close to being significant (p=0,07), while the percieved support of a communicative work-climate in New Zealand companies was insignificant (p=0,21). No survey participants from New Zealand or Germany found that their company was not doing anything regarding knowledge management.

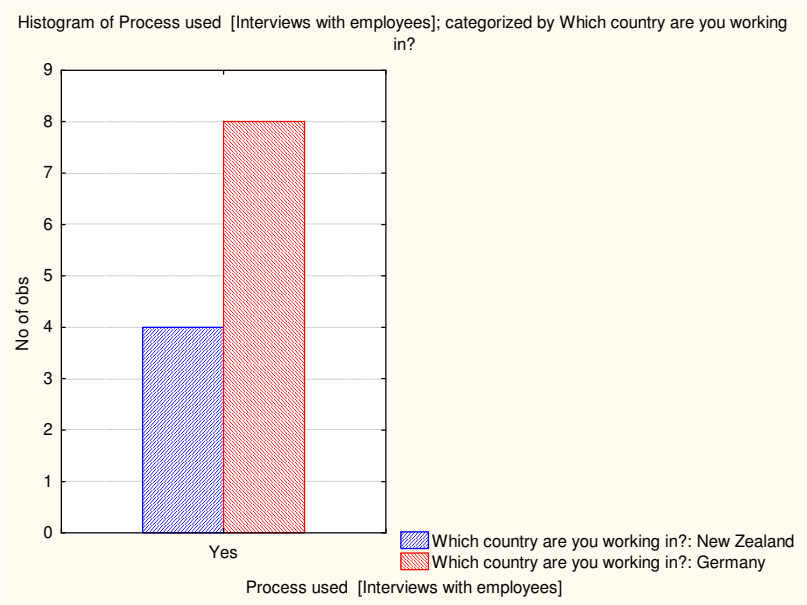


Figure 30

The difference shown in *Figure 30* are close to being significant (see *Figure 31,* ANOVA p=0.07).

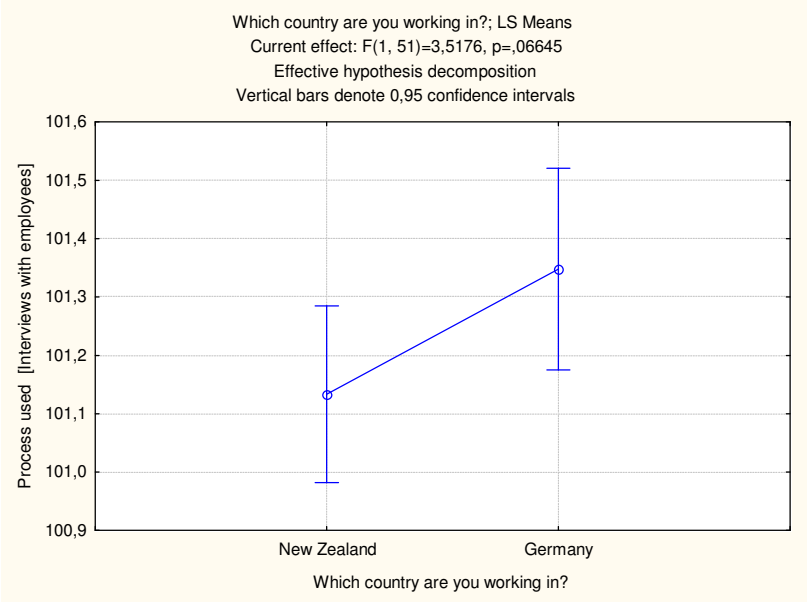


Figure 31

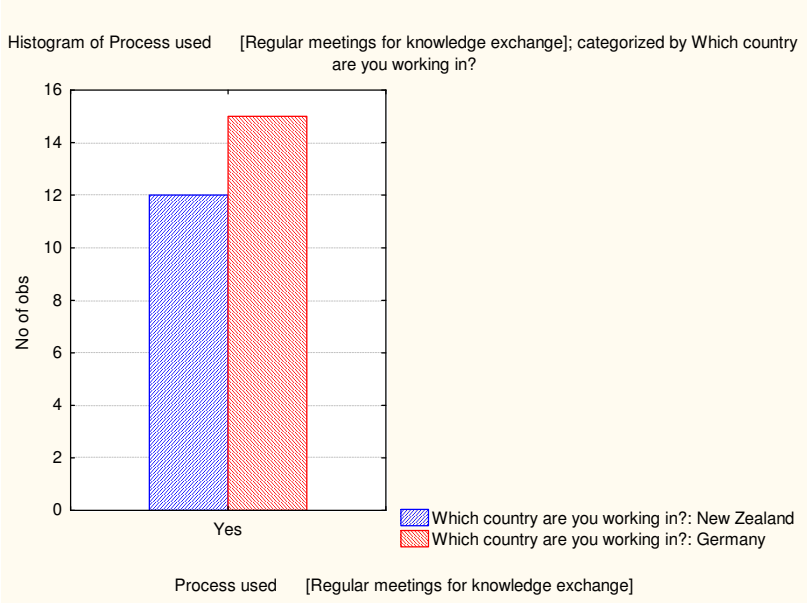


Figure 32

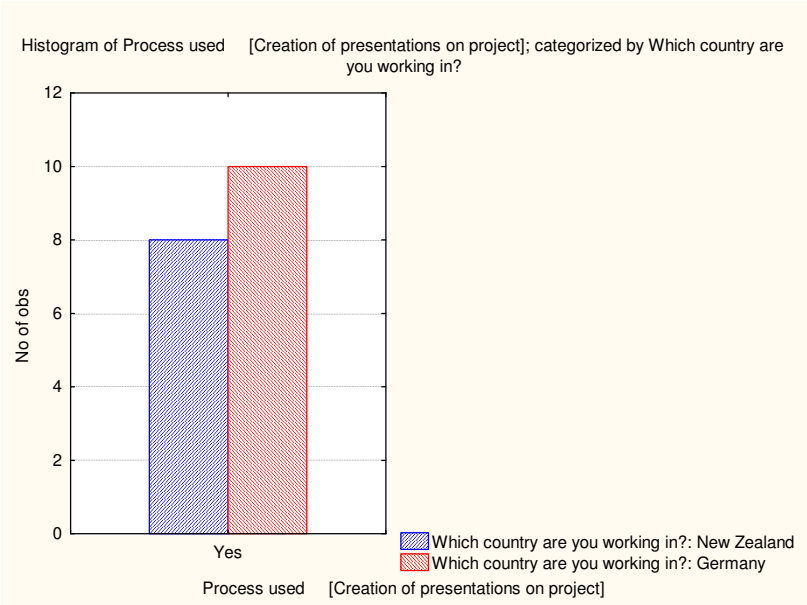


Figure 33

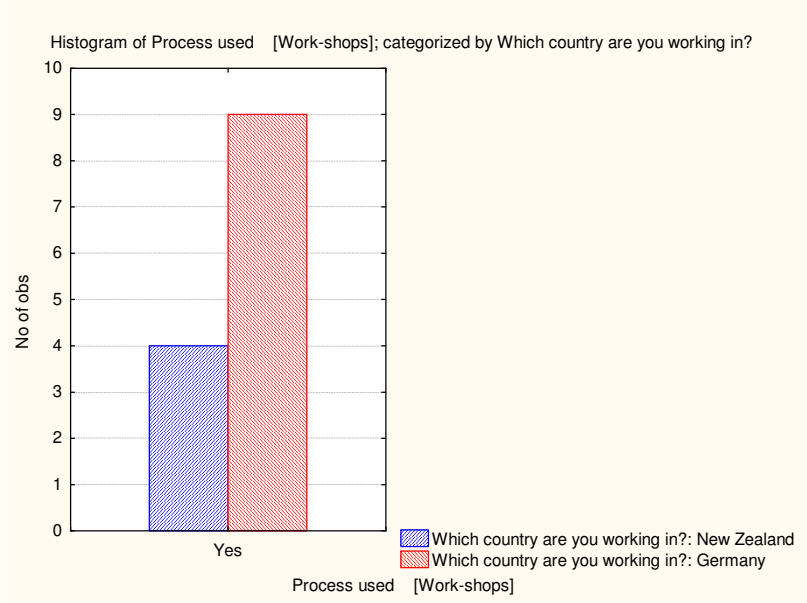


Figure 34

Work-shops seem to be more common in German companies than in New Zealand. According to ANOVA the difference is statistically significant (see *Figure 35*, p=0.03).

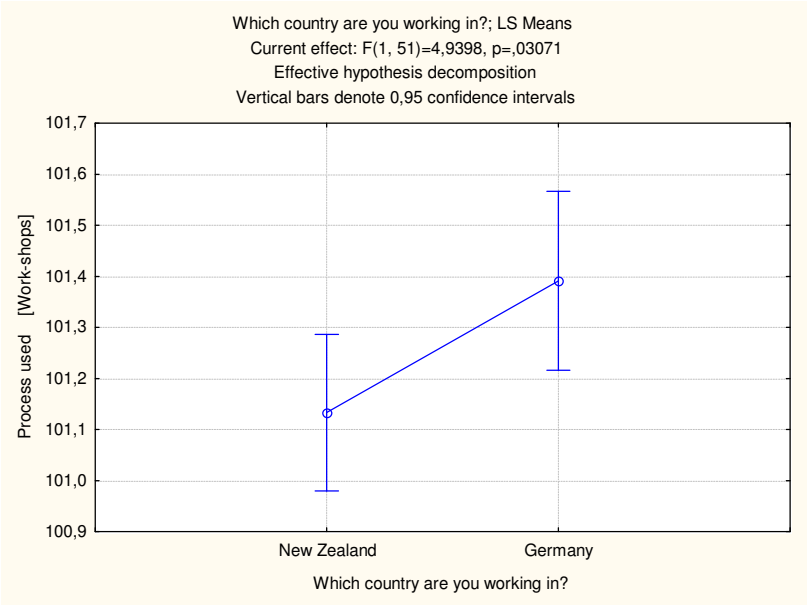


Figure 35

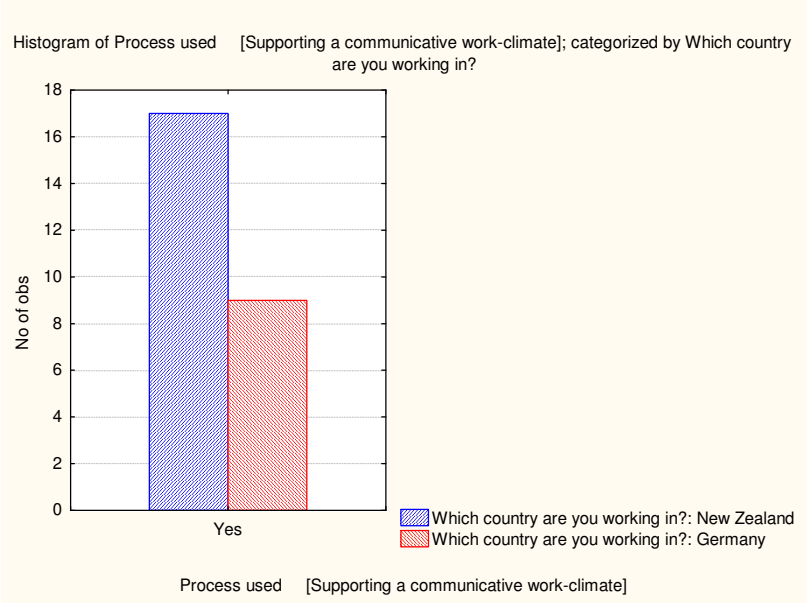


Figure 36

The difference shown in *Figure 36* for the support of a communicative work-climate in companies in both countries are statistically insignificant (see *Figure 37*, ANOVA p=0.21).

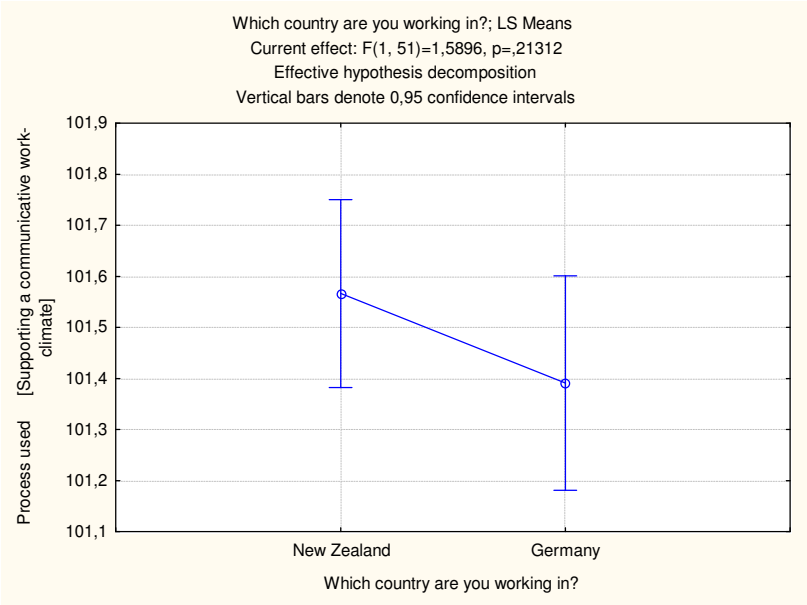


Figure 37

2.6 How did your firm decide which KM methods to use?

The majority of survey respondents thought that the KM strategies of their firm basically developed somehow organically without well set clear direction. However, some stated that it was a systematic approach or that the direction was set through managers or consultants.

2.7 To what extent is this approach successful?

On the whole the respondents felt that the KM practices in their organisations were rather successful, see *Figure 38*. However, many people felt KM that only a moderate success was achieved. More participants stated that their KM approach was not successful at all or just successful to a small extent than very successful. This suggests that it may be difficult to fully reach the potential of KM.

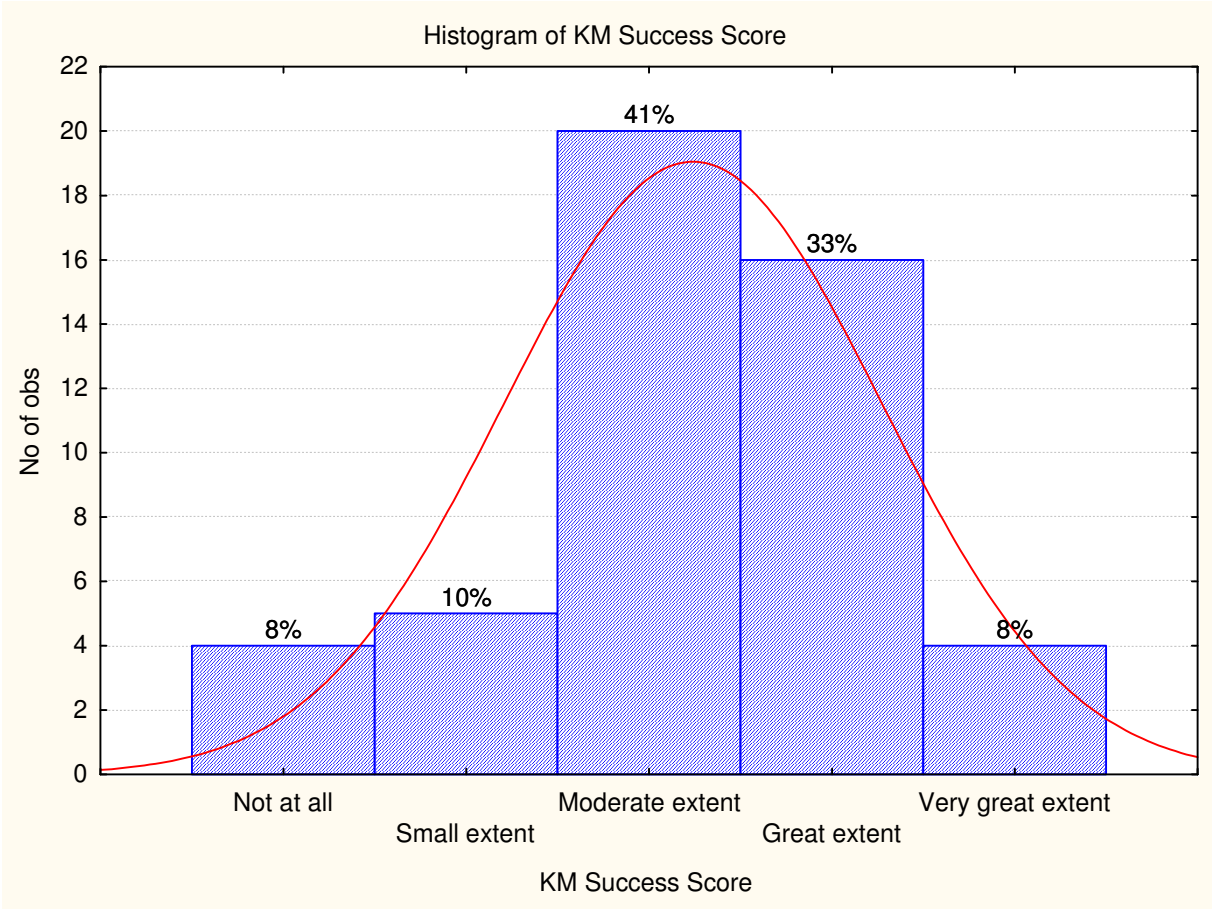


Figure 38

2.7.1 Comparison between NZ and Germany

There is a small observed difference between NZ and GER. The NZ respondents tended to be more positive about the success of KM. New Zealanders tended to respond more negatively and less positively, see *Figure 39*. However, some New Zealanders found that their knowledge management was very successful (great extent – very great success). GER has a mean success rate for KM that is slightly higher. However, this is not statistically significant (ANOVA result p=0.92), see *Figure 40*.

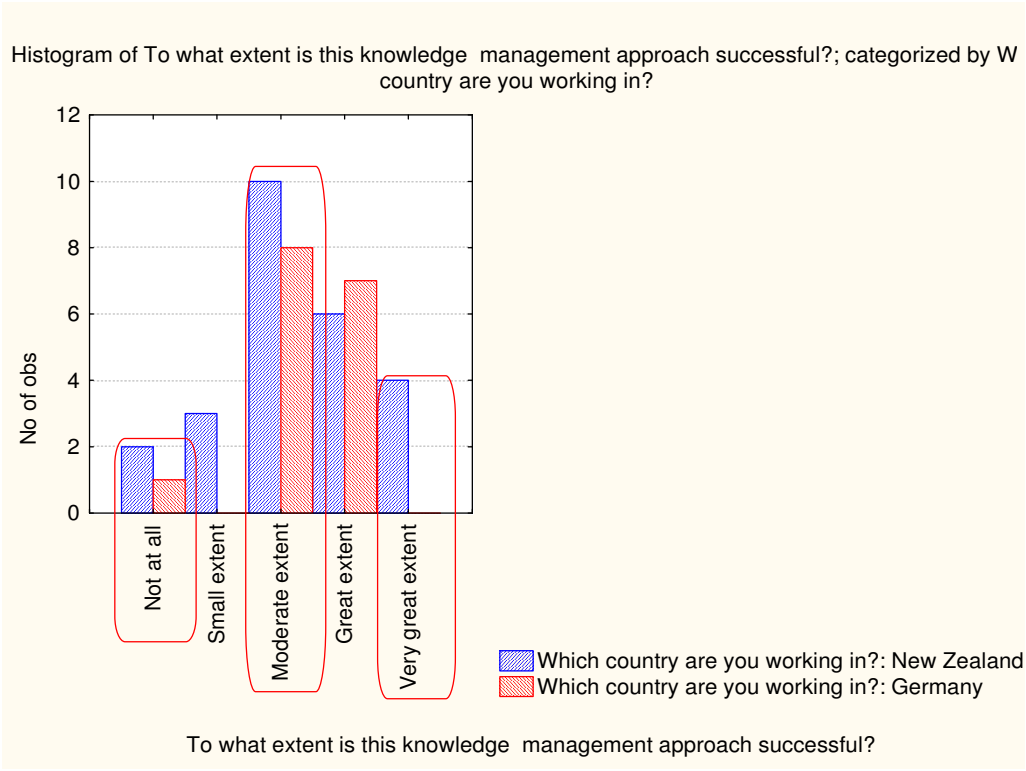


Figure 39

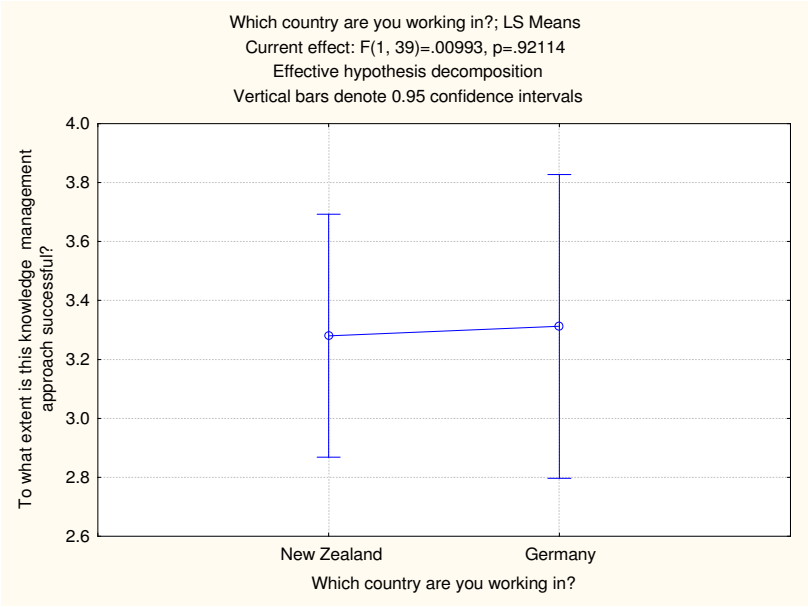


Figure 40

2.7.2 Association of KM success and particular KM processes

The data mining algorithm for sequence and association link analysis (SAL) was used to explore the associations between KM success and a number of variables.

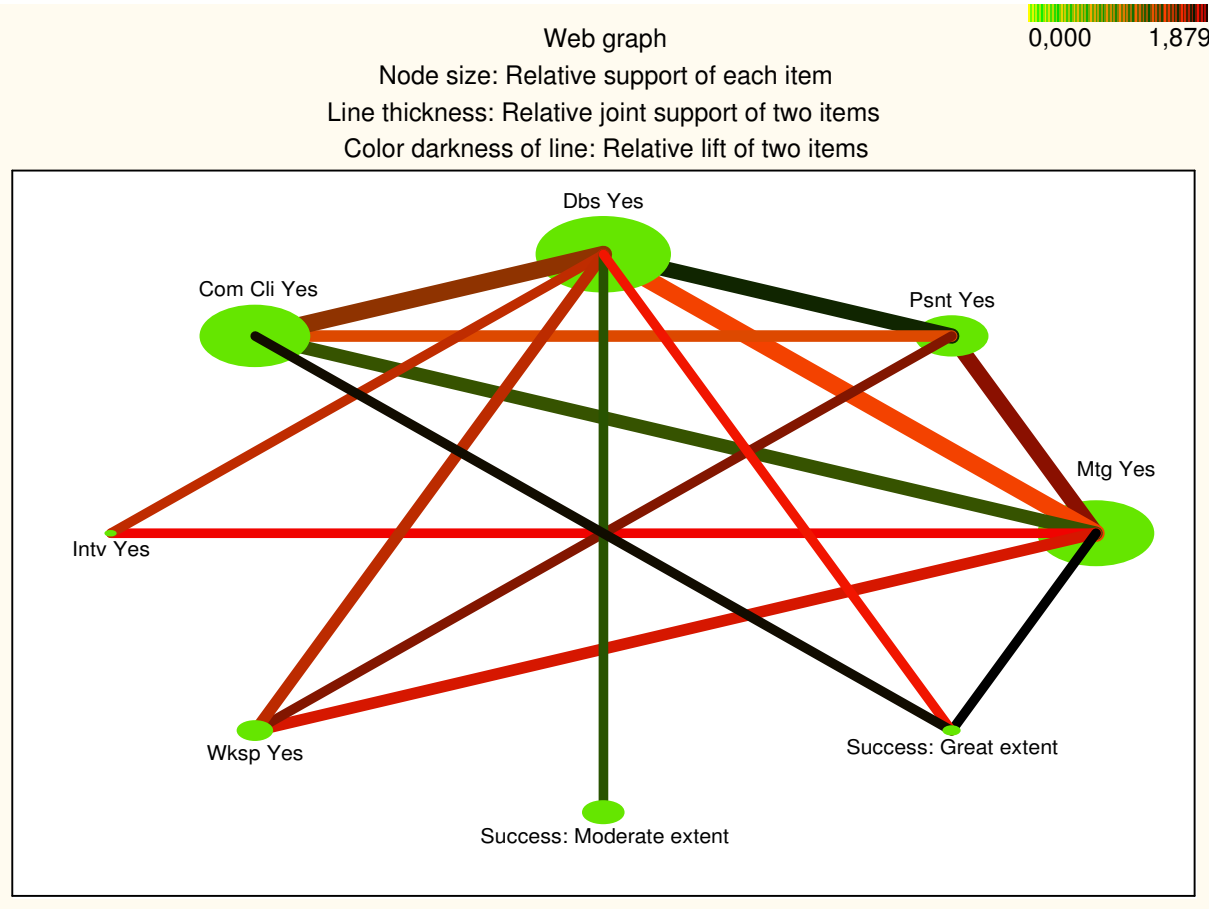


Figure 41: SAL results for KM processes vs KM success. Support min 0.15, confidence 0.15.

The results showed an association between a moderate KM success and the creation of a database. Great KM success was not only associated with the creation of a database, but also with regular meetings and the support of a communicative work-climate. Also the results did show the association *between* the different methods. For example, a communicative culture was associated with having a database, meetings and presentations (but not particularly with workshops or interviews).

Summary of association rules (University of Canterbury Resear in Workbook_1.09.stw) Min: support = 15,0%, confidence = 15,0% Max. size of an itemset = 10

	Body	== >	Head	Support(%)	Confidence(%)	Lift
1	Success: Great extent	== >	Mtg Yes	17,56757	81,2500	1,878906
2	Mtg Yes	==	Success: Great extent	17,56757	40,6250	1,87890

		>				6
3	Wksp Yes	==>	Mtg Yes	18,91892	73,6842	1,703947
4	Mtg Yes	==>	Wksp Yes	18,91892	43,7500	1,703947
5	Wksp Yes	==>	Mtg Yes, Dbs Yes	14,86486	57,8947	2,040100
6	Dbs Yes	==>	Mtg Yes, Wksp Yes	14,86486	31,4286	1,661224
7	Dbs Yes, Wksp Yes	==>	Mtg Yes	14,86486	78,5714	1,816964
8	Mtg Yes	==>	Dbs Yes, Wksp Yes	14,86486	34,3750	1,816964
9	Mtg Yes, Wksp Yes	==>	Dbs Yes	14,86486	78,5714	1,661224
10	Mtg Yes, Dbs Yes	==>	Wksp Yes	14,86486	52,3810	2,040100
11	Intv Yes	==>	Mtg Yes	16,21622	80,0000	1,850000
12	Mtg Yes	==>	Intv Yes	16,21622	37,5000	1,850000
13	Com Cli Yes	==>	Mtg Yes	22,97297	54,8387	1,268145
14	Mtg Yes	==>	Com Cli Yes	22,97297	53,1250	1,268145
15	Com Cli Yes	==>	Mtg Yes, Dbs Yes	16,21622	38,7097	1,364055
16	Dbs Yes	==>	Mtg Yes, Com Cli Yes	16,21622	34,2857	1,492437
17	Dbs Yes, Com Cli Yes	==>	Mtg Yes	16,21622	54,5455	1,261364
18	Mtg Yes	==>	Dbs Yes, Com Cli Yes	16,21622	37,5000	1,261364
19	Mtg Yes, Com Cli Yes	==>	Dbs Yes	16,21622	70,5882	1,492437
20	Mtg Yes, Dbs Yes	==>	Com Cli Yes	16,21622	57,1429	1,364055
21	Com Cli Yes	==>	Mtg Yes, Psnt Yes	16,21622	38,7097	1,507640
22	Psnt Yes	==>	Mtg Yes, Com Cli Yes	16,21622	48,0000	2,089412
23	Psnt Yes, Com Cli Yes	==>	Mtg Yes	16,21622	85,7143	1,982143
24	Mtg Yes	==>	Psnt Yes, Com Cli Yes	16,21622	37,5000	1,982143
25	Mtg Yes, Com Cli Yes	==>	Psnt Yes	16,21622	70,5882	2,089412
26	Mtg Yes, Psnt Yes	==>	Com Cli Yes	16,21622	63,1579	1,507640

27	Com Cli Yes	==>	Mtg Yes, Psnt Yes, Dbs Yes	16,21622	38,7097	1,685009
28	Dbs Yes	==>	Mtg Yes, Psnt Yes, Com Cli Yes	16,21622	34,2857	2,114286
29	Dbs Yes, Com Cli Yes	==>	Mtg Yes, Psnt Yes	16,21622	54,5455	2,124402
30	Psnt Yes	==>	Mtg Yes, Dbs Yes, Com Cli Yes	16,21622	48,0000	2,960000
31	Psnt Yes, Com Cli Yes	==>	Mtg Yes, Dbs Yes	16,21622	85,7143	3,020408
32	Psnt Yes, Dbs Yes	==>	Mtg Yes, Com Cli Yes	16,21622	63,1579	2,749226
33	Psnt Yes, Dbs Yes, Com Cli Yes	==>	Mtg Yes	16,21622	85,7143	1,982143
34	Mtg Yes	==>	Psnt Yes, Dbs Yes, Com Cli Yes	16,21622	37,5000	1,982143
35	Mtg Yes, Com Cli Yes	==>	Psnt Yes, Dbs Yes	16,21622	70,5882	2,749226
36	Mtg Yes, Dbs Yes	==>	Psnt Yes, Com Cli Yes	16,21622	57,1429	3,020408
37	Mtg Yes, Dbs Yes, Com Cli Yes	==>	Psnt Yes	16,21622	100,0000	2,960000
38	Mtg Yes, Psnt Yes	==>	Dbs Yes, Com Cli Yes	16,21622	63,1579	2,124402
39	Mtg Yes, Psnt Yes, Com Cli Yes	==>	Dbs Yes	16,21622	100,0000	2,114286
40	Mtg Yes, Psnt Yes, Dbs Yes	==>	Com Cli Yes	16,21622	70,5882	1,685009
41	Dbs Yes	==>	Mtg Yes	28,37838	60,0000	1,387500
42	Mtg Yes	==>	Dbs Yes	28,37838	65,6250	1,387500
43	Dbs Yes	==>	Mtg Yes, Psnt Yes	22,97297	48,5714	1,891729
44	Psnt Yes	==>	Mtg Yes, Dbs Yes	22,97297	68,0000	2,396190
45	Psnt Yes, Dbs Yes	==>	Mtg Yes	22,97297	89,4737	2,069079
46	Mtg Yes	==>	Psnt Yes, Dbs Yes	22,97297	53,1250	2,069079
47	Mtg Yes, Dbs Yes	==>	Psnt Yes	22,97297	80,9524	2,396190
48	Mtg Yes, Psnt Yes	==>	Dbs Yes	22,97297	89,4737	1,891729
49	Psnt Yes	==>	Mtg Yes	25,67568	76,0000	1,757500
50	Mtg Yes	==>	Psnt Yes	25,67568	59,3750	1,757500
5	Wksp Yes	==	Psnt Yes	14,86486	57,8947	1,71368

1		>				4
52	Psnt Yes	==>	Wksp Yes	14,86486	44,0000	1,713684
53	Com Cli Yes	==>	Psnt Yes	18,91892	45,1613	1,336774
54	Psnt Yes	==>	Com Cli Yes	18,91892	56,0000	1,336774
55	Com Cli Yes	==>	Psnt Yes, Dbs Yes	18,91892	45,1613	1,758913
56	Dbs Yes	==>	Psnt Yes, Com Cli Yes	18,91892	40,0000	2,114286
57	Dbs Yes, Com Cli Yes	==>	Psnt Yes	18,91892	63,6364	1,883636
58	Psnt Yes	==>	Dbs Yes, Com Cli Yes	18,91892	56,0000	1,883636
59	Psnt Yes, Com Cli Yes	==>	Dbs Yes	18,91892	100,0000	2,114286
60	Psnt Yes, Dbs Yes	==>	Com Cli Yes	18,91892	73,6842	1,758913
61	Dbs Yes	==>	Psnt Yes	25,67568	54,2857	1,606857
62	Psnt Yes	==>	Dbs Yes	25,67568	76,0000	1,606857
63	Success: Great extent	==>	Dbs Yes	17,56757	81,2500	1,717857
64	Dbs Yes	==>	Success: Great extent	17,56757	37,1429	1,717857
65	Success: Moderate extent	==>	Dbs Yes	16,21622	60,0000	1,268571
66	Dbs Yes	==>	Success: Moderate extent	16,21622	34,2857	1,268571
67	Wksp Yes	==>	Dbs Yes	18,91892	73,6842	1,557895
68	Dbs Yes	==>	Wksp Yes	18,91892	40,0000	1,557895
69	Intv Yes	==>	Dbs Yes	14,86486	73,3333	1,550476
70	Dbs Yes	==>	Intv Yes	14,86486	31,4286	1,550476
71	Com Cli Yes	==>	Dbs Yes	29,72973	70,9677	1,500461
72	Dbs Yes	==>	Com Cli Yes	29,72973	62,8571	1,500461
73	Success: Great extent	==>	Com Cli Yes	16,21622	75,0000	1,790323
74	Com Cli Yes	==>	Success: Great extent	16,21622	38,7097	1,790323

Figure 42

2.8 If your company does not fully use KM practices, why is that?

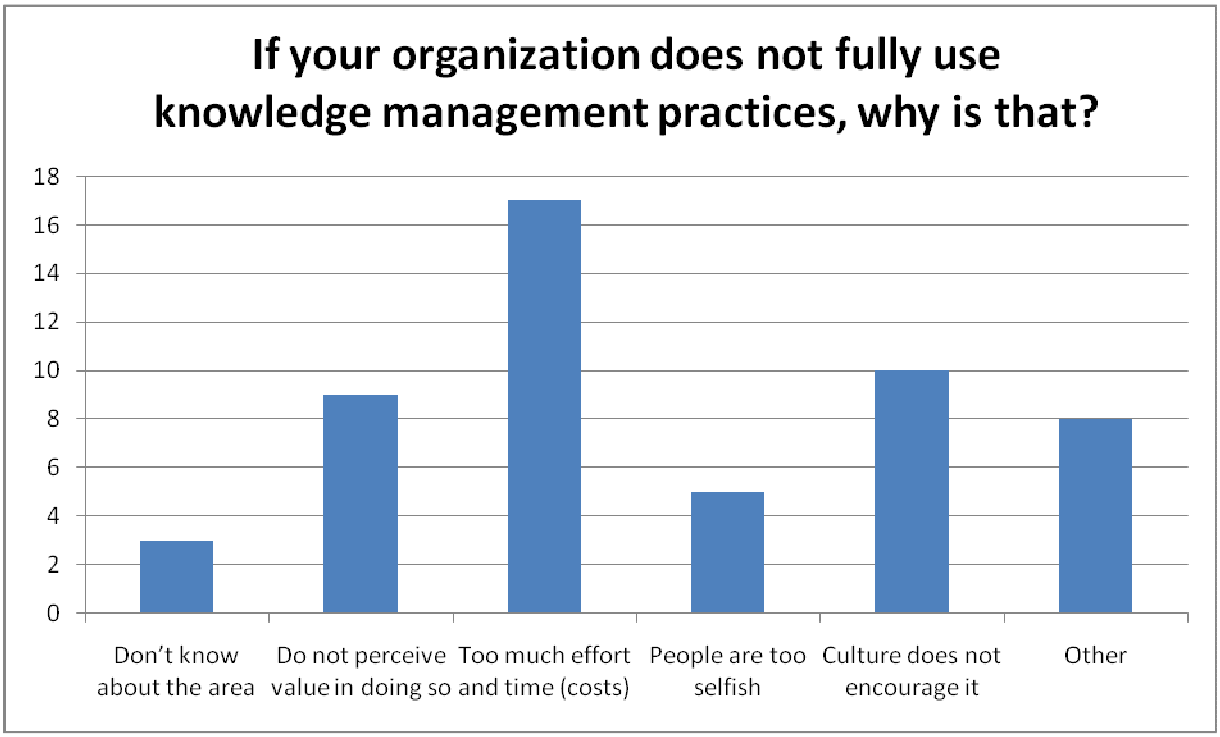


Figure 43

2.8.1 Comparison between New Zealand and Germany

There are two major differences that can be found between respondents from New Zealand and Germany. New Zealanders were more likely to perceive only a low value in using knowledge management practices. This difference is statistically insignificant acoording to ANOVA (see *Figure 46*, p=0.1). Germans on the other hand tended to find that knowledge management practices were difficult to use, because people tend to be too selfish while no New Zealander mentioned this to be an issue for their knowledge management. This result is statistically significant (see *Figure 49* , ANOVA p=0.02).

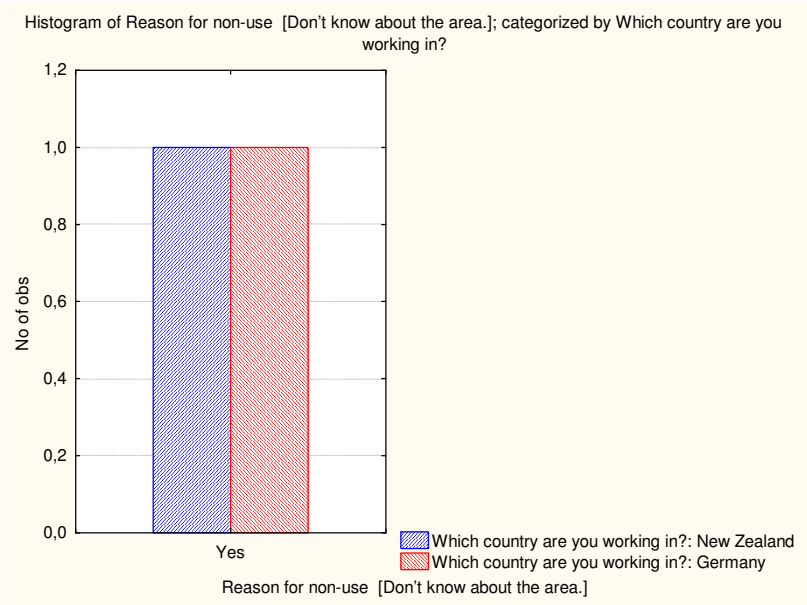


Figure 44

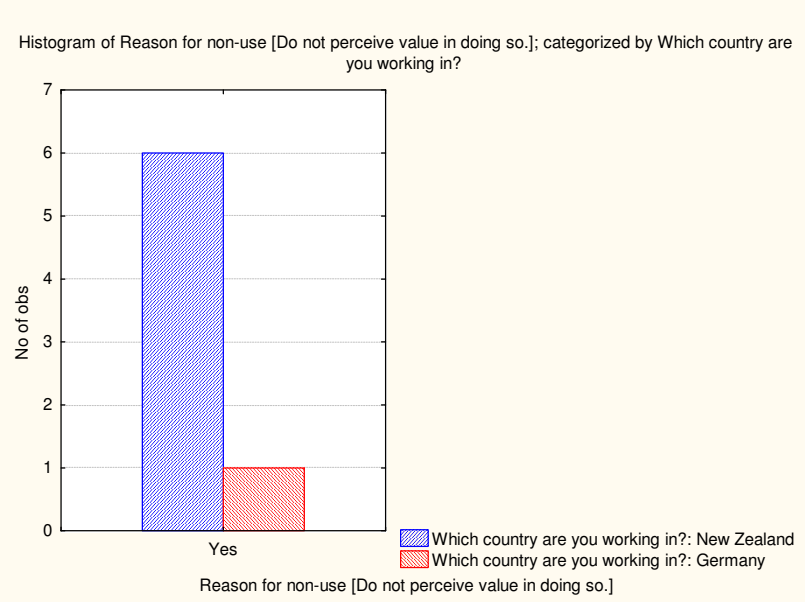


Figure 45

The difference shown in *Firgure 44* is statistically insignificant (see *Figure 45*, ANOVA p=0.1).

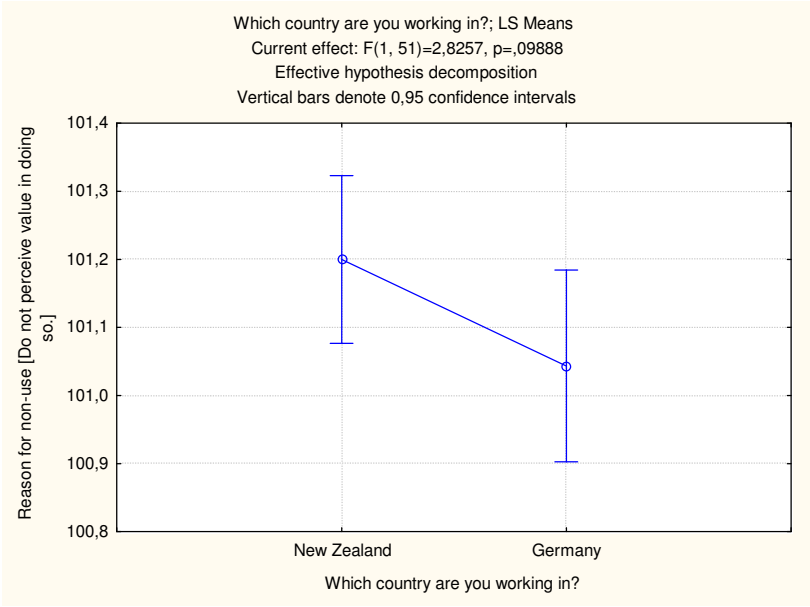


Figure 46

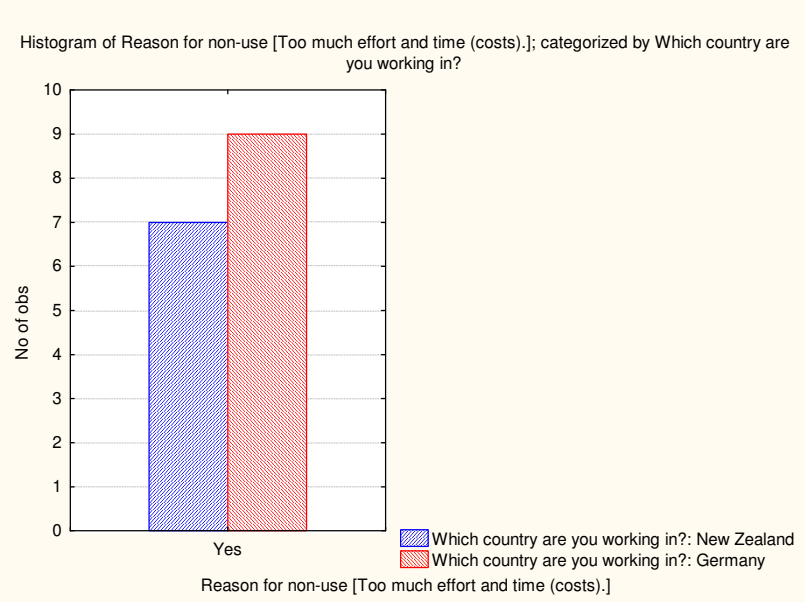


Figure 47

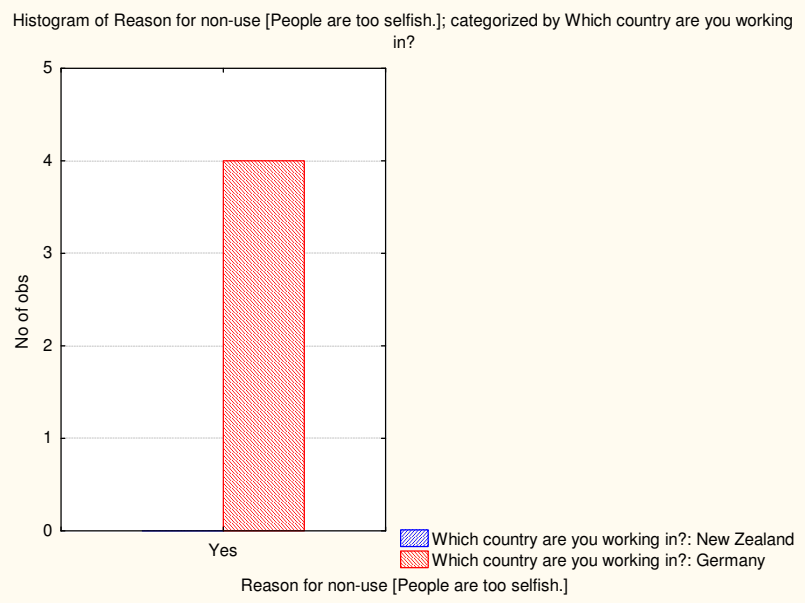


Figure 48

While no survey respondent from New Zealand found that selfishness of others was a problem for their KM practices, this tendency could be seen for people in Germany. Not many people considered this a problem, however, the difference between both countries is statistically significant (see *Figure 49,* ANOVA p=0.02).

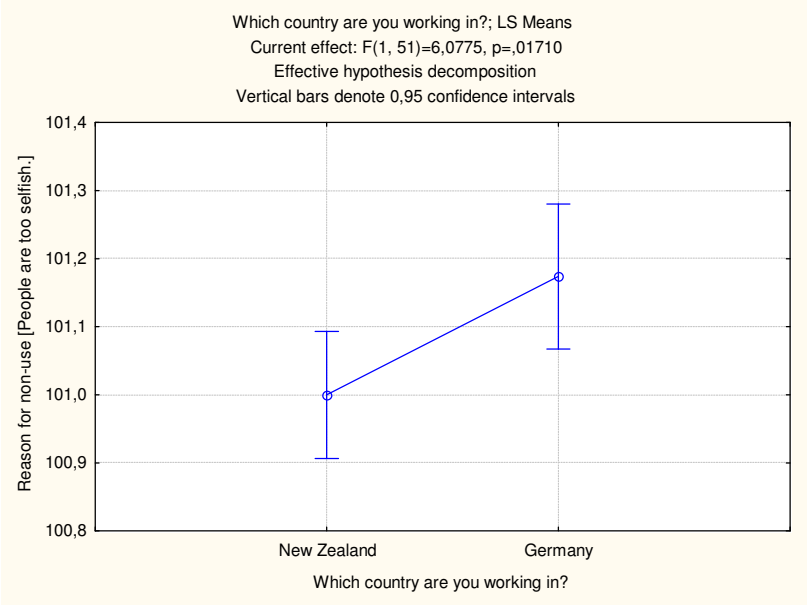


Figure 49

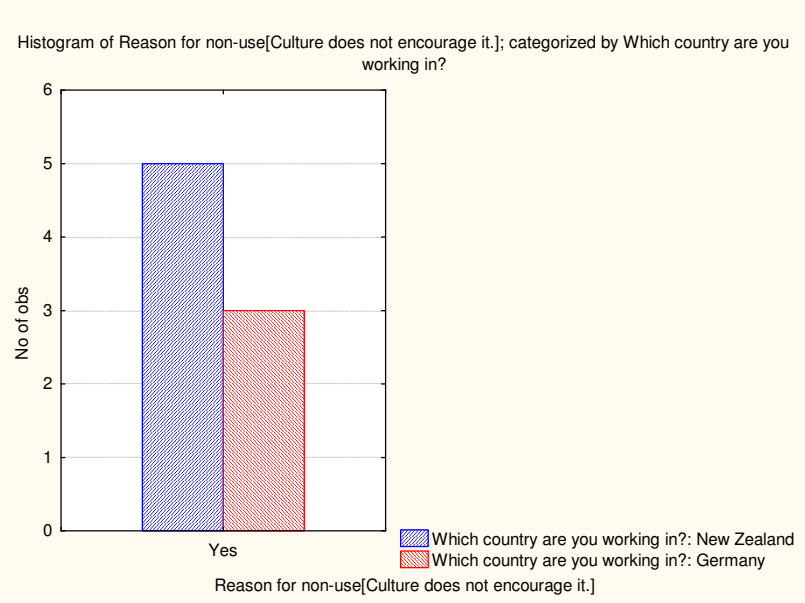

Histogram of Reason for non-use[Culture does not encourage it.]; categorized by Which country are you working in?
No of obs
0
1
2
3
4
5
6
Yes
Which country are you working in?: New Zealand
Which country are you working in?: Germany
Reason for non-use[Culture does not encourage it.]

Figure 50

2.9 To what extent does your company formally measure its intellectual capital?

Figure 51 shows that most companies tend to not measure their intellectual capital formally. 33% stated that they did not measure it at all.

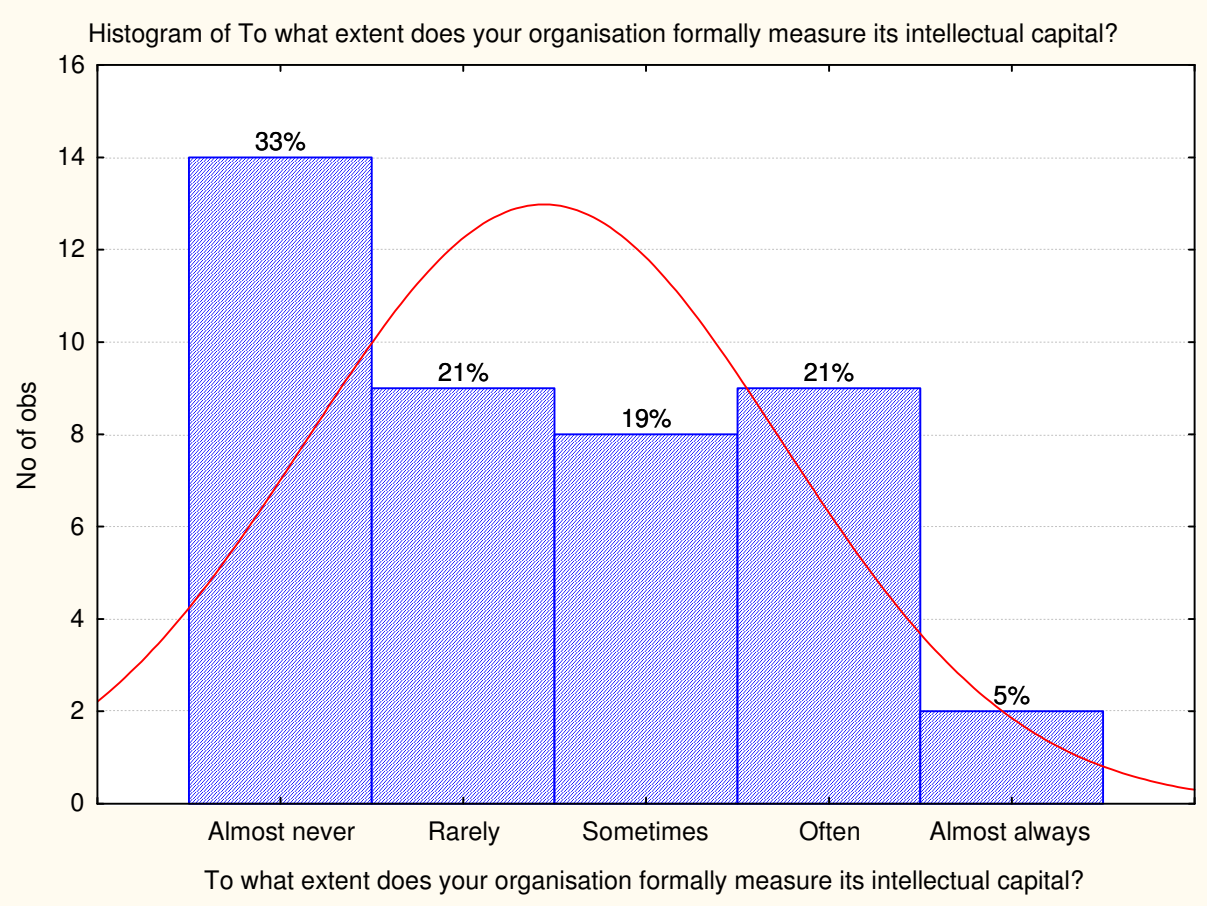


Figure 51

2.9.1 Comparison between New Zealand and Germany

Figure 52 shows that companies in New Zealand tend to measure their intellectual capital to a lower extent than German companies. But according to ANOVA the differences are statistically insignificant (p=0.58).

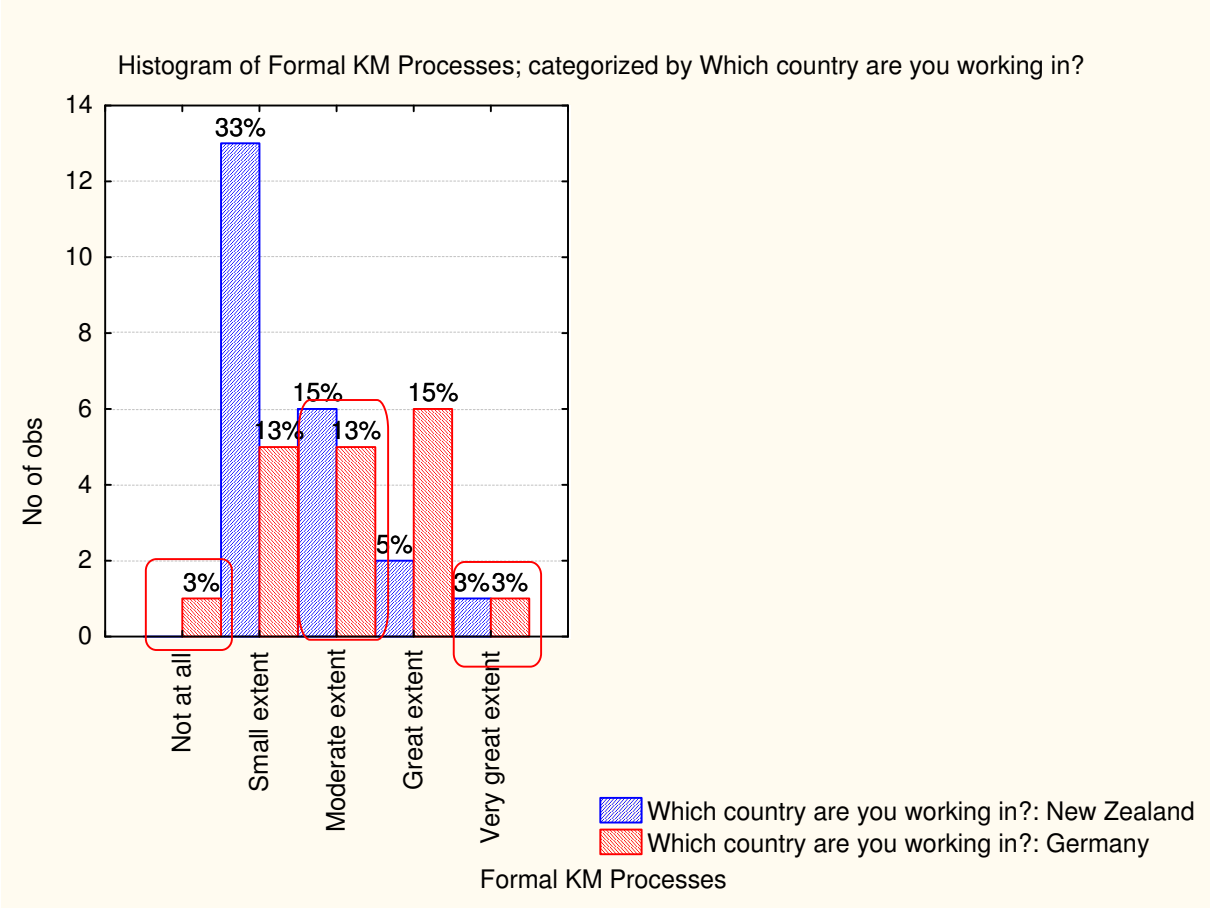


Figure 52

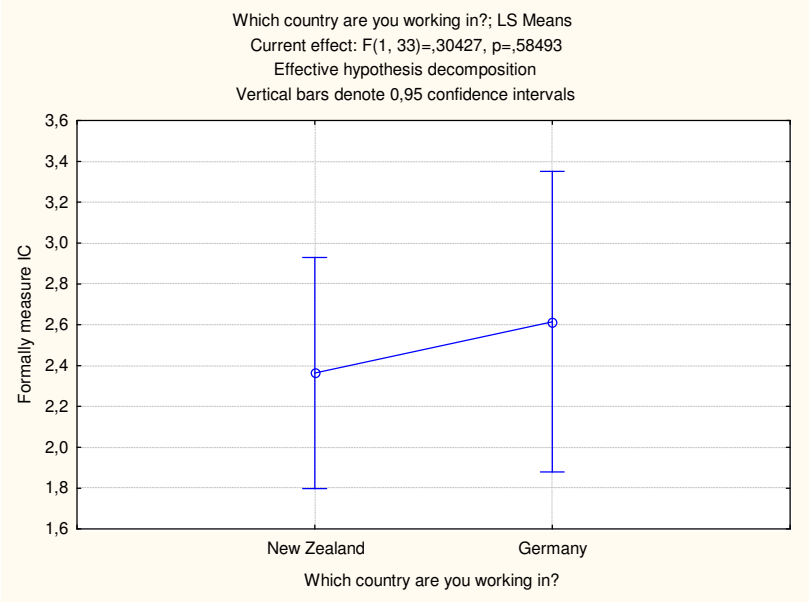


Figure 53

2.9.2 Association with KM success

The results showed that a moderate extent of knowledge management can be associated with a low activity to formally measure intellectual capital (almost never). This could indicate a lower awareness of knowledge management, a lower perceived value of knowledge and intellectual capital resulting in unsatisfying knowledge management success.

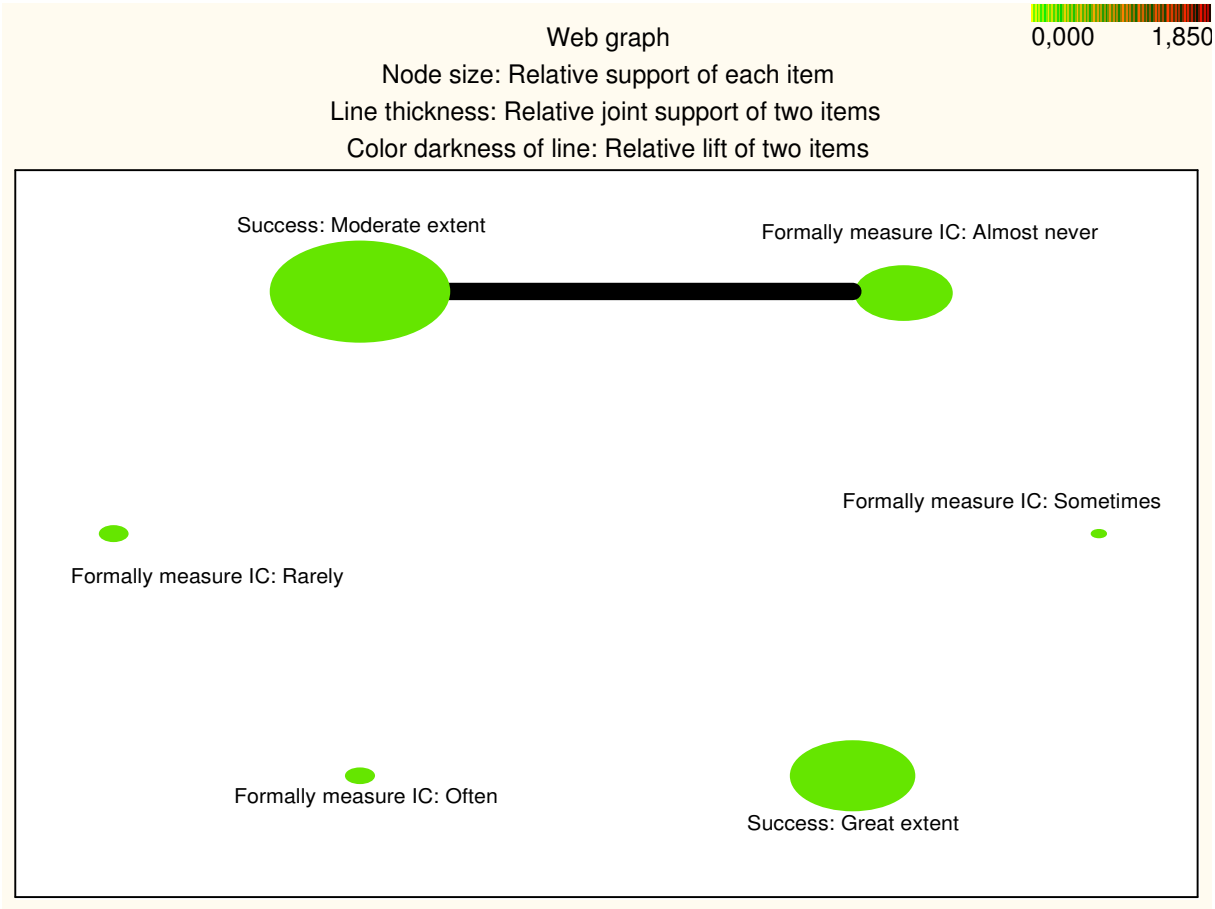


Figure 54: SAL results for KM processes vs formal measure. Support min 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.09.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Success: Moderate extent	==>	Formally measure IC: Almost never	9,459459	35,00000	1,850000
2	Formally measure IC: Almost never	==>	Success: Moderate extent	9,459459	50,00000	1,850000

Figure 55

3 Your practices

3.1 How easy is it for you to find and access stored knowledge?

Most survey respondents found that stored knowledge was accessible with moderate ease or easily. However, 29% of the survey participants thought that it was difficult to find stored knowledge., see *Figure 56*.

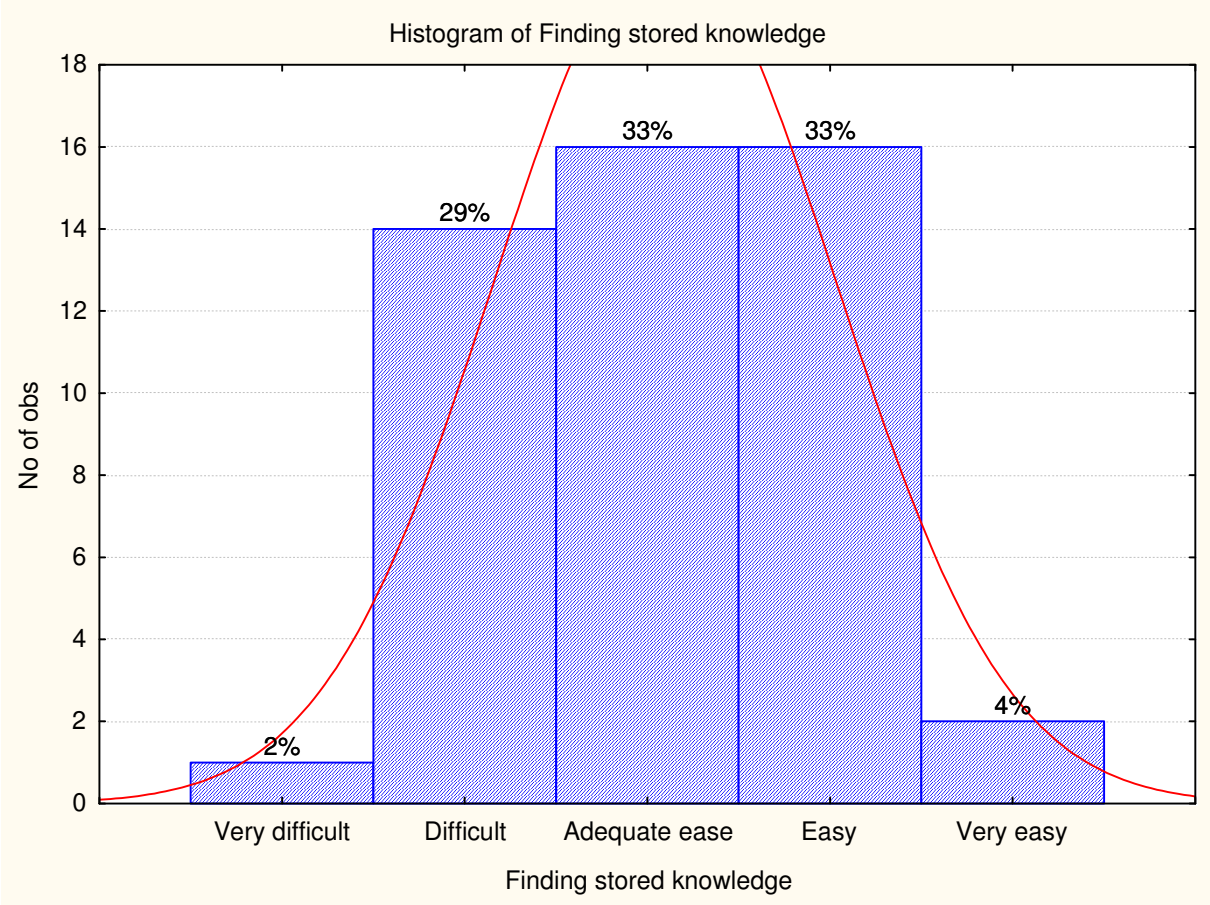


Figure 56

3.1.1 Comparison between New Zealand and Germany

No significant difference between New Zealand and German companies could be found, see *Figure 57*.

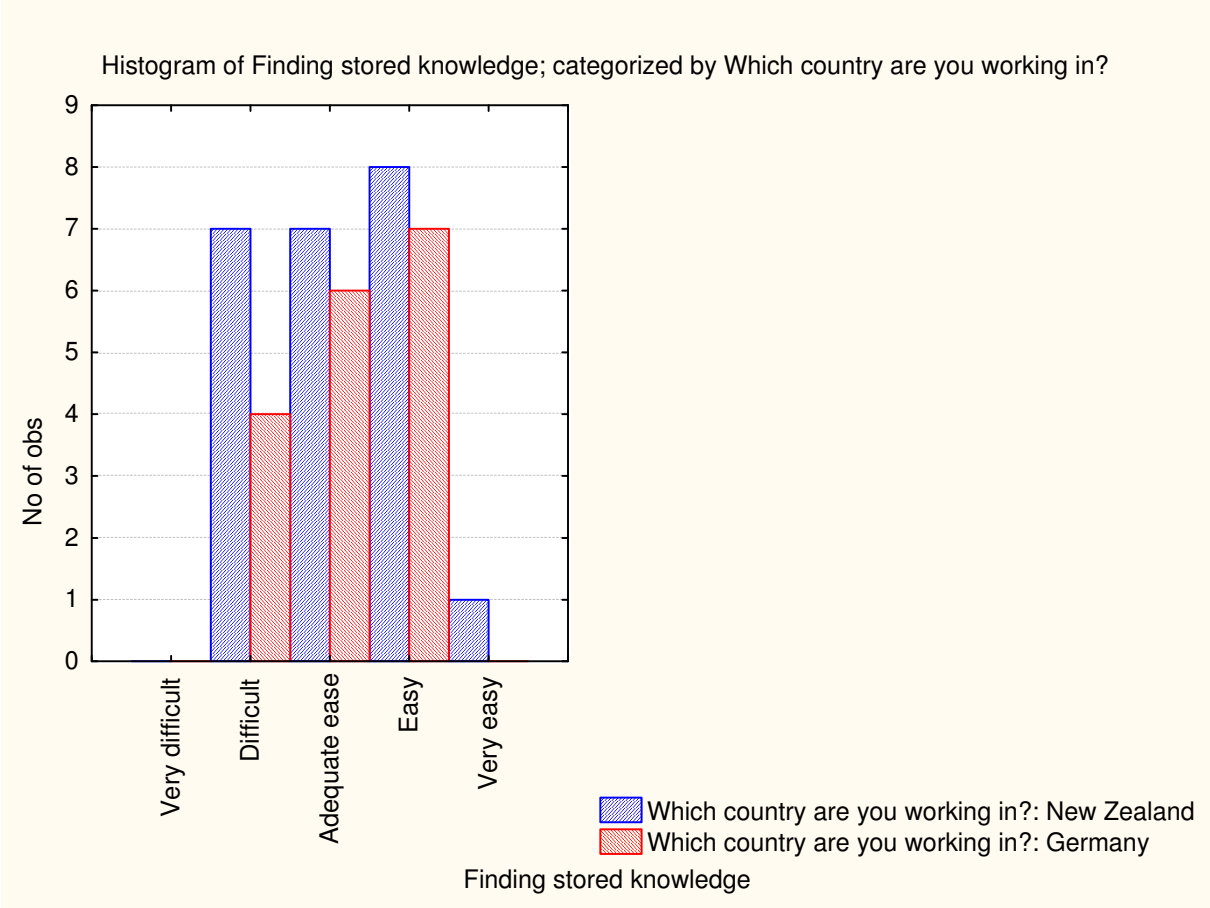


Figure 57

3.2 What are the problems (if any) in your company regarding KM as you see them?

Survey respondents found that by far the most significant problem was that there was no clear KM strategy in their company.

3.3 How often do you use KM practices?

Most survey respondents use knowledge management practices often or at least sometimes. But almost every fourth person stated that they rarely or never used KM practices (24%), see *Figure 58*.

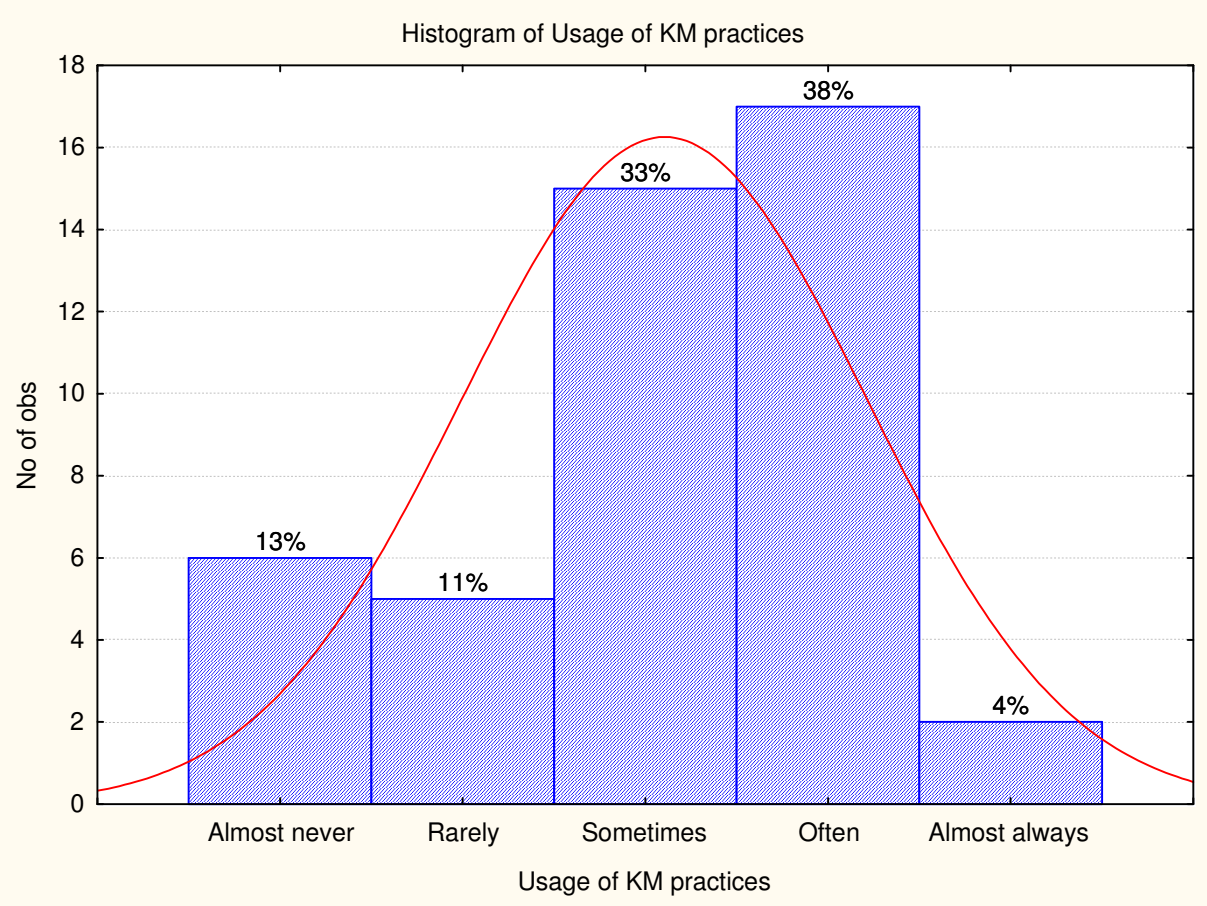


Figure 58

3.3.1 Comparison between New Zealand and Germany

No significant difference between New Zealanders and Germans can be found, see *Figure 59*. There are a few more positive responses of New Zealand survey participants, but it has to be considered that the number of responses from both countries was not equal.

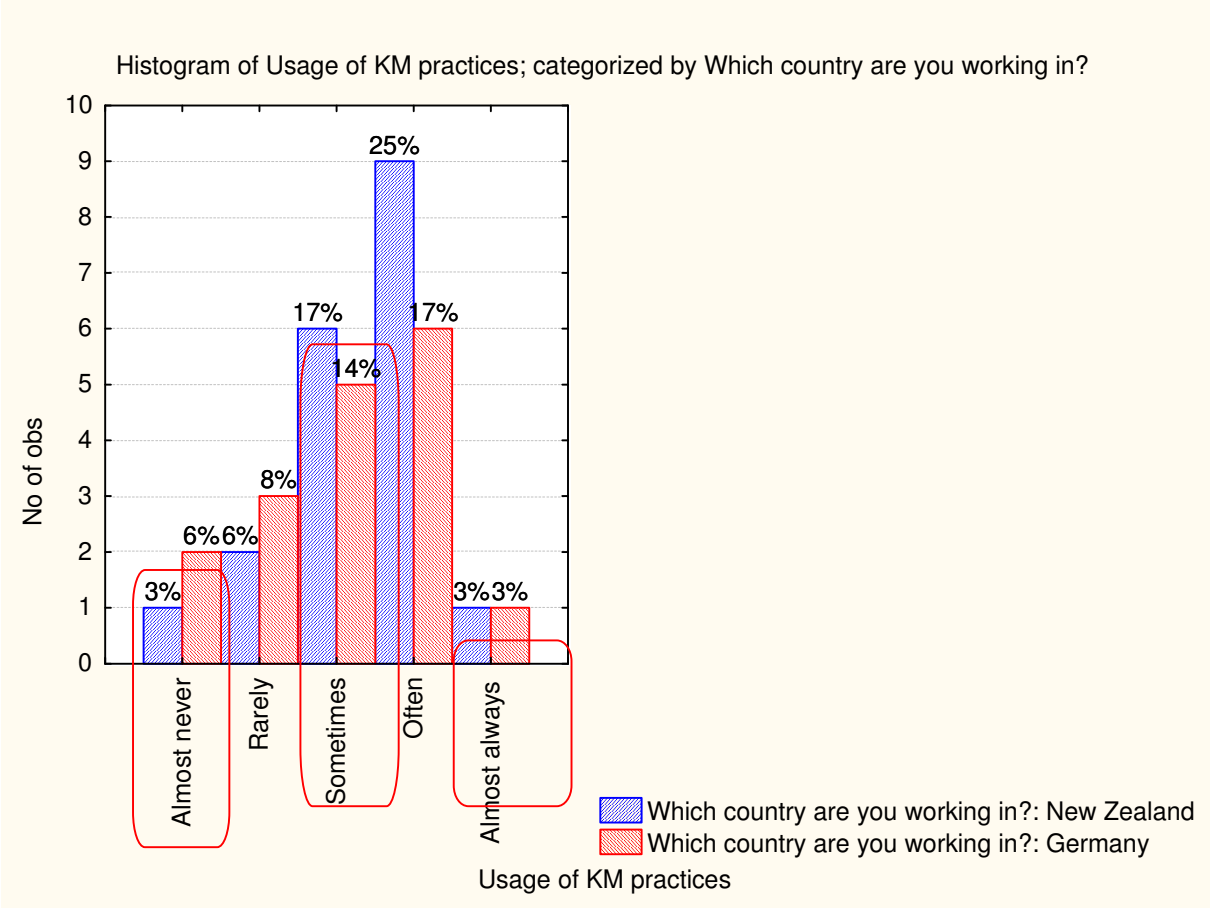


Figure 59

3.4 Which KM practices (if any) do you personally find helpful in your job?

Survey respondents mentioned codification strategies (e.g. intranet, database) and personalization strategies (e.g. meetings and discussions) helpful for their jobs.

3.5 How important is KM for the successful completion of your job?

On the whole most people found that knowledge management was very important for their jobs. 80% of the participants answered it was somewhat important to very important, see Figure 60.

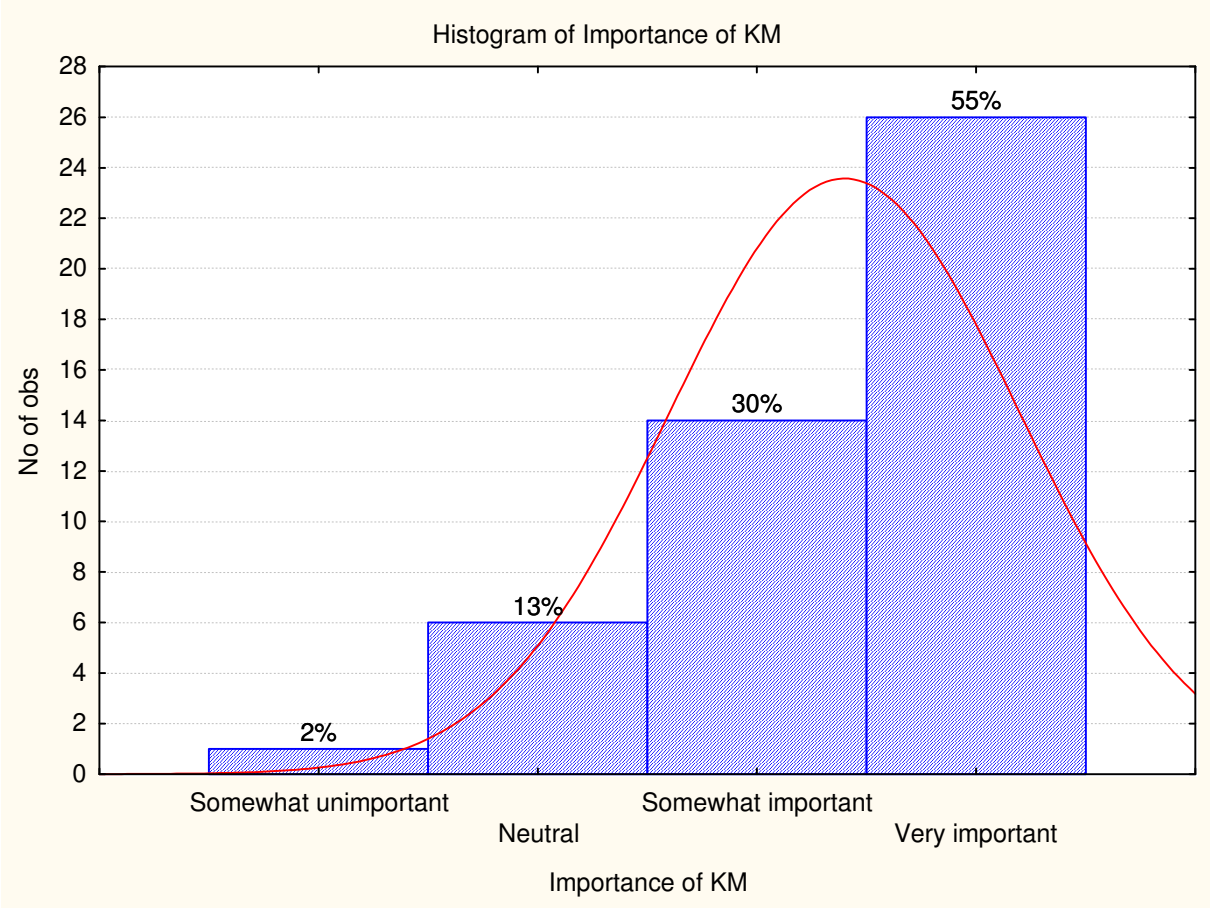


Figure 60

3.5.1 Comparison between New Zealand and Germany

New Zealanders seemed to rate the KM importance slightly higher than German survey respondents, see *Figure 61*. But it is not a statistically significant result (p=0.76).

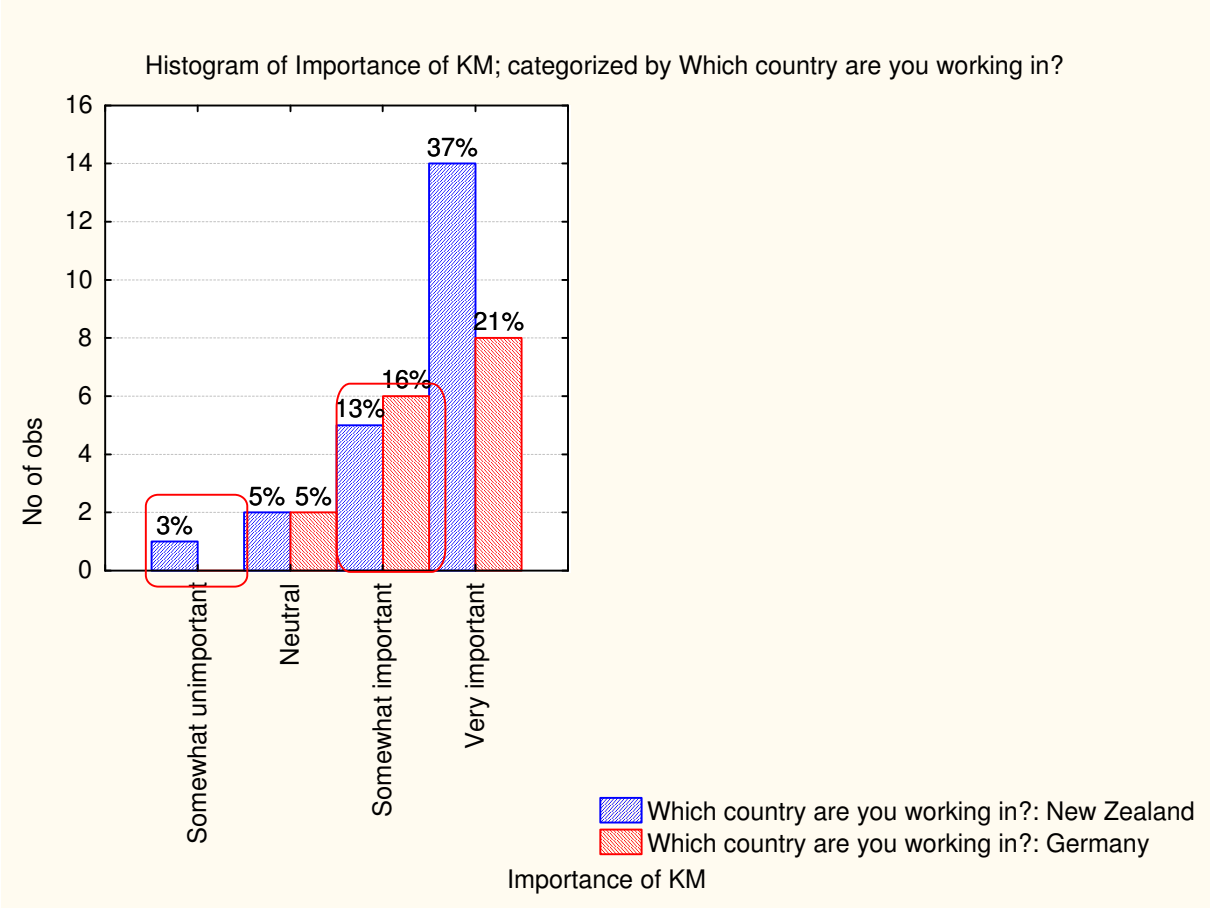


Figure 61

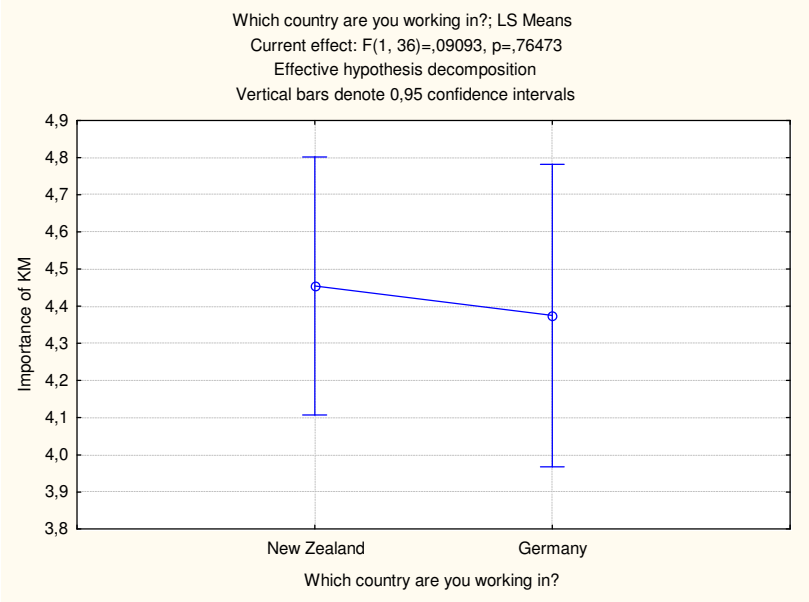


Figure 62

3.6 What do you think are the benefits of KM for your company and the employees?

Survey respondents thought that the main benefits of KM were a higher efficiency, and saving time and money.

3.7 To what extent does your firm use formal knowledge-capture processes?

Figure 63 shows that almost half of the respondents (48%) found that their company only formally measures its intellectual capital to a small extent. 26% think their organization formally measures its IC to a moderate extent while only 25% rate the extent as high (great to very great extent).

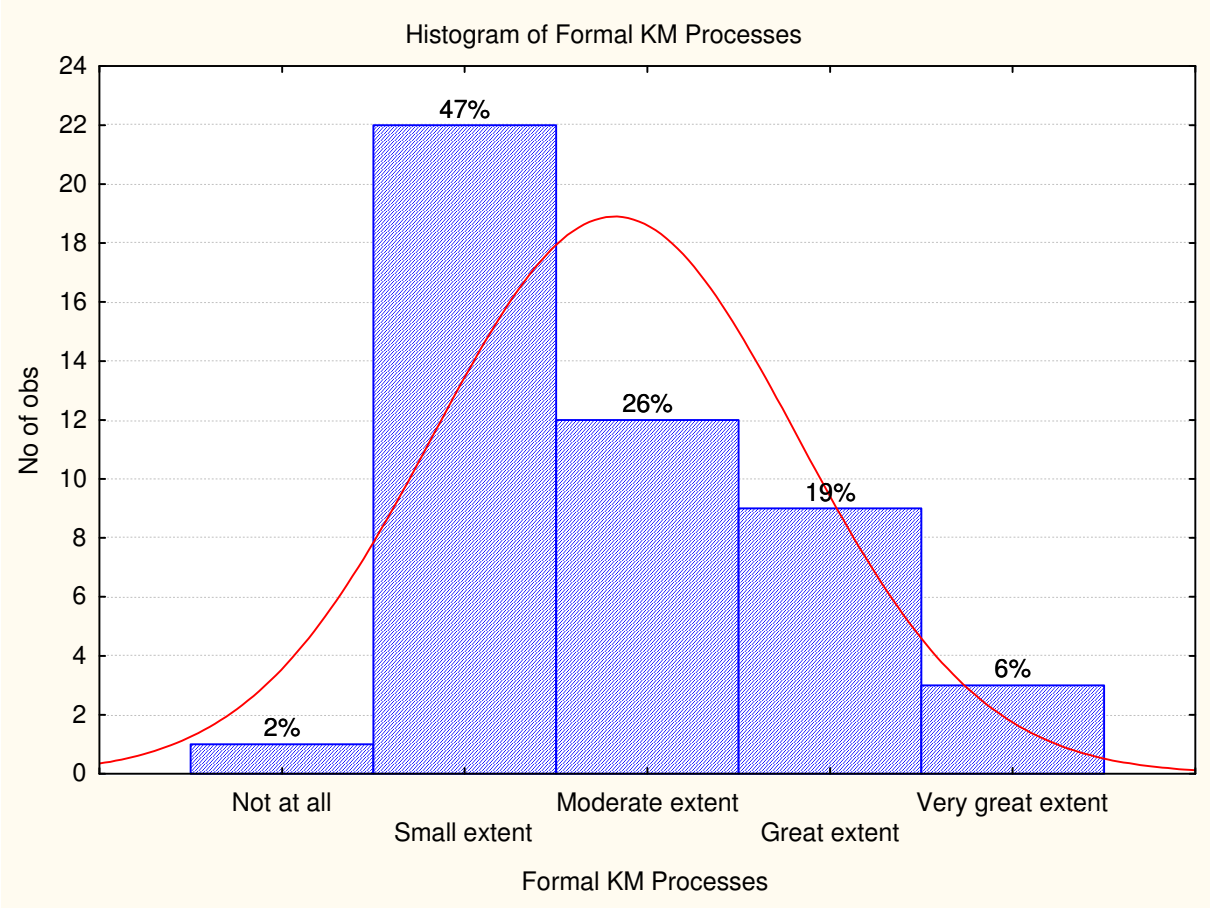


Figure 63

3.7.1 Comparison between New Zealand and Germany

The comparison between New Zealand and Germany showed that Germans tend to measure the intellectual capital of their companies to a greater extent, however on the whole they did not find that it was measured to a great extent either., see *Figure 64*. New Zealanders tended to be more negative. But no statistically significant difference could be found (p=0.58).

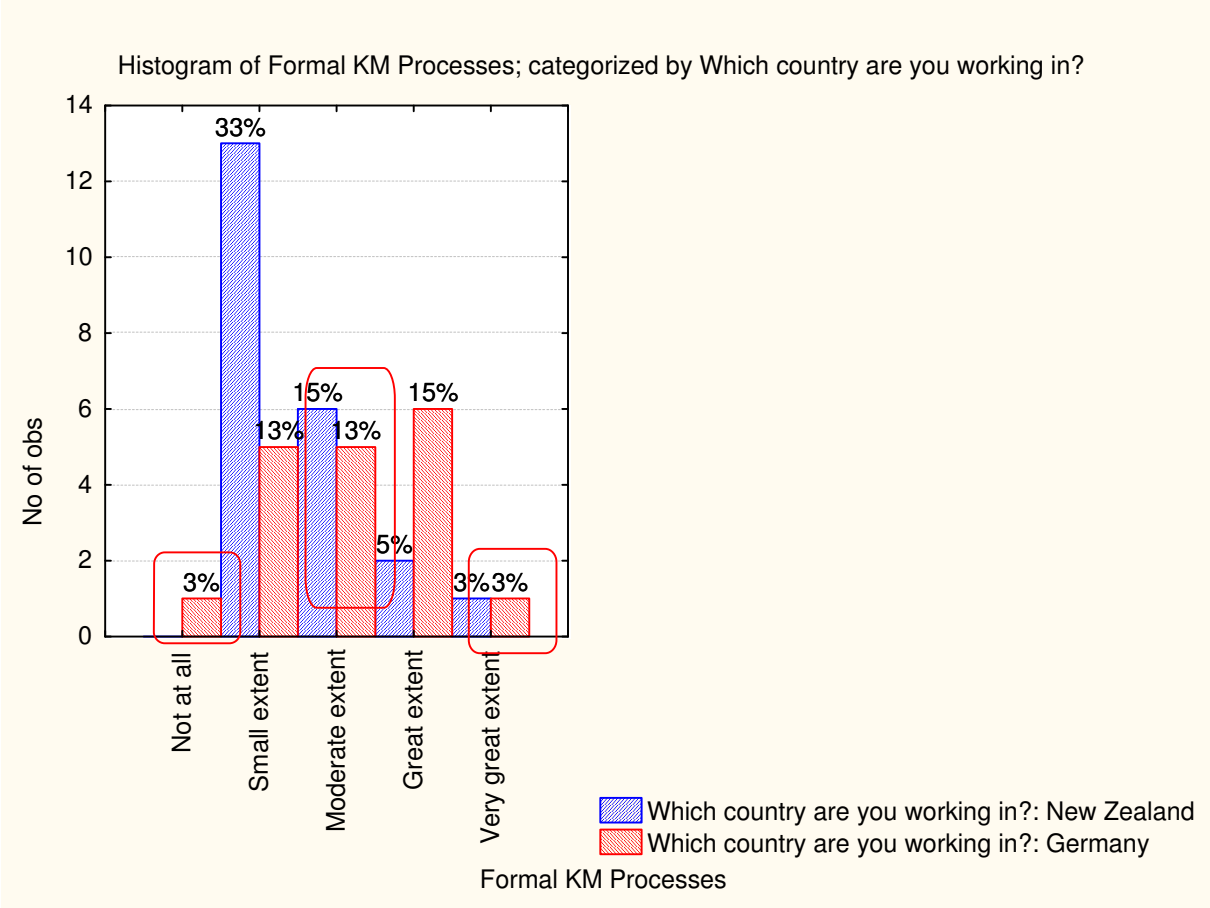


Figure 64

Figure 65

4 Personal sharing of knowledge

4.1 What does your firm do to encourage people to share their knowledge?

The most common practices in NPD companies to encourage employees to share their knowledge are the support of a communicative work-climate, active encouragement to share knowledge and regular meetings for knowledge exchange, see *Figure 66*.

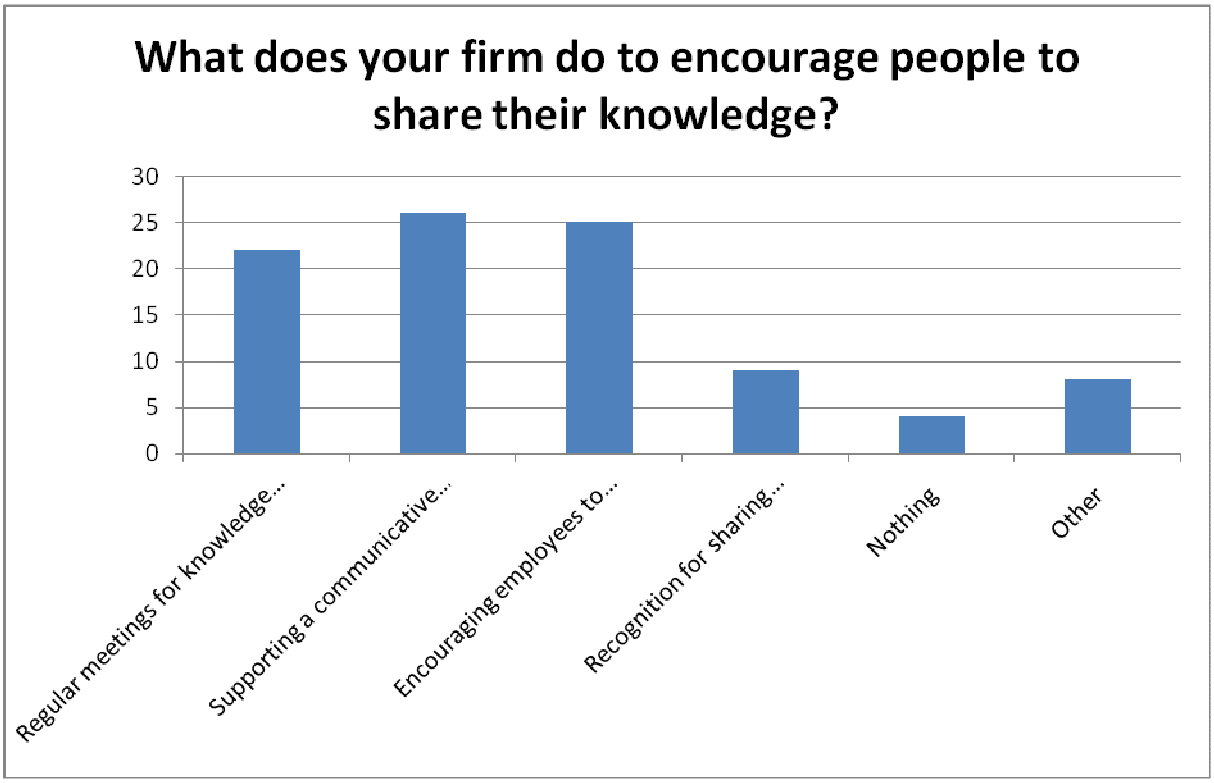


Figure 66

4.1.1 Comparison between New Zealand and Germany

On the whole regular meetings and recognition for sharing knowledge seem to be more common practices in German companies. The difference regarding regular meetings was proved statistically significant (see *Figure 68* , ANOVA p=0.05), while the difference regarding recognition for sharing knowledge was found statistically insignificant (see *Figure 72* , ANOVA p=0.11).

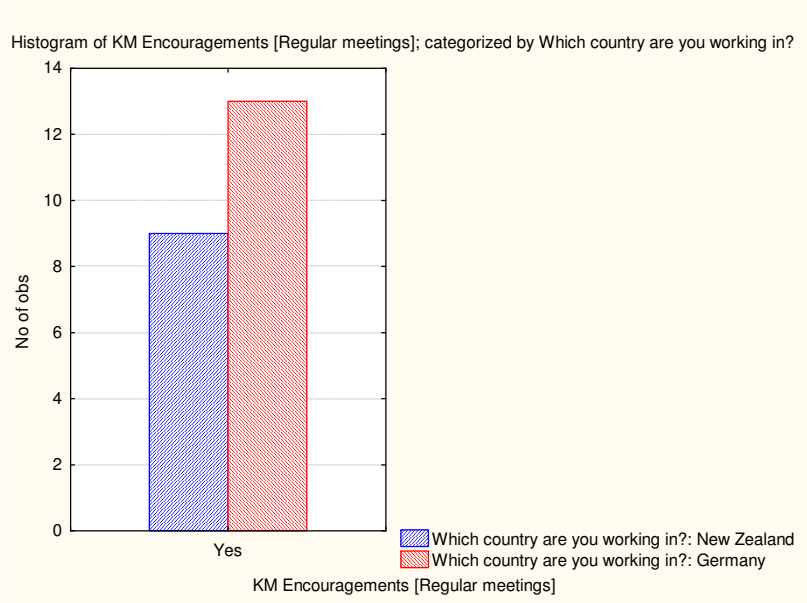


Figure 67

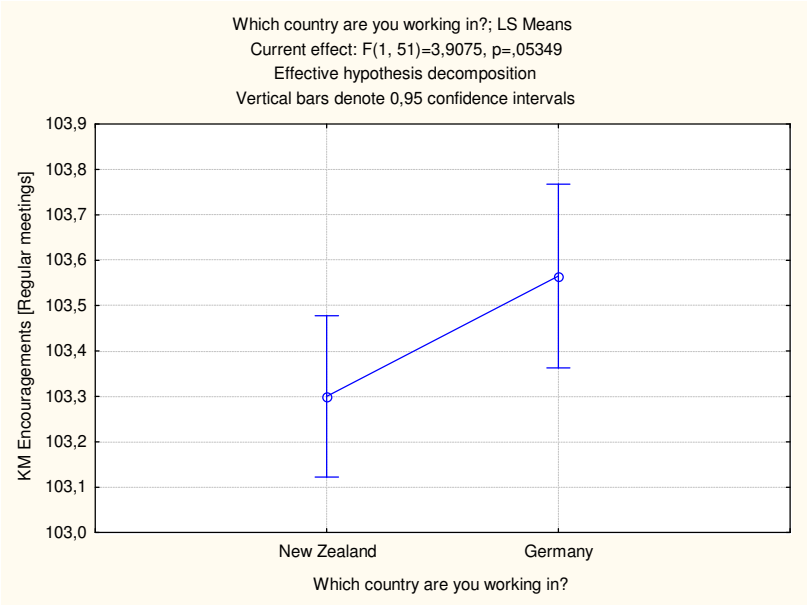


Figure 68

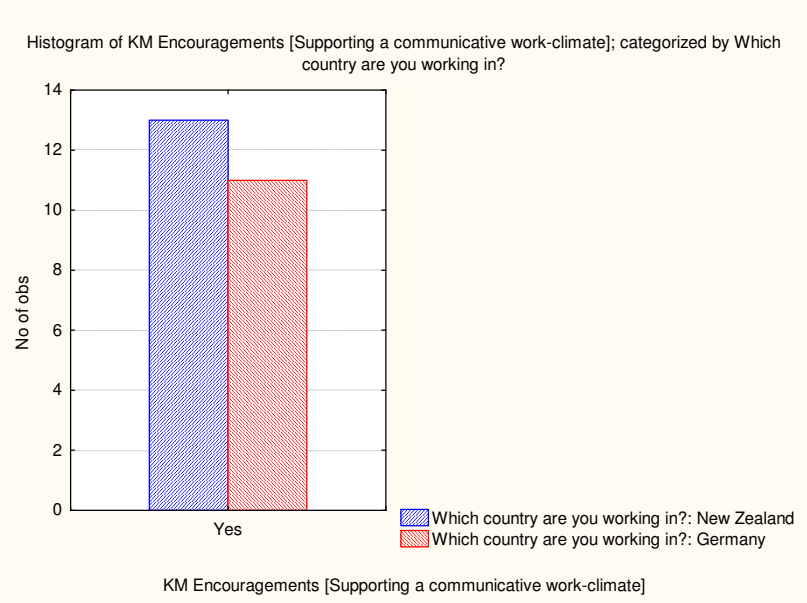


Figure 69

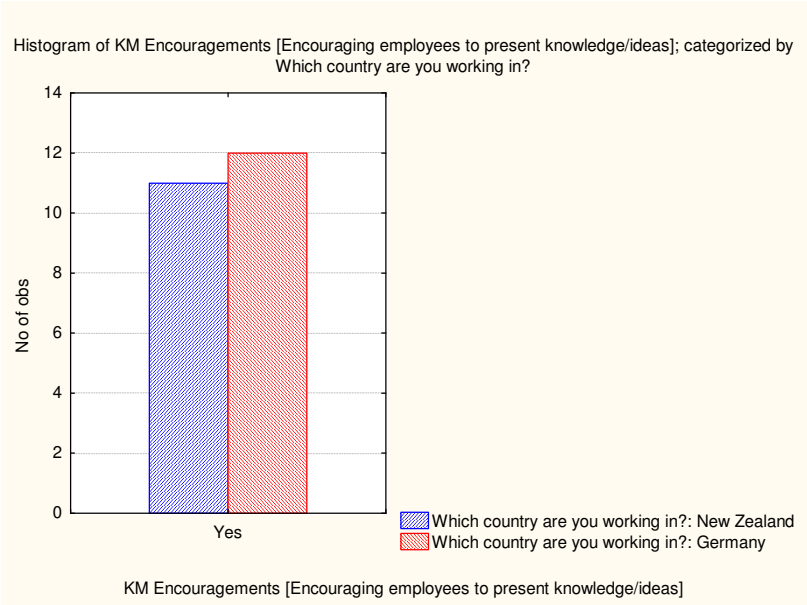


Figure 70

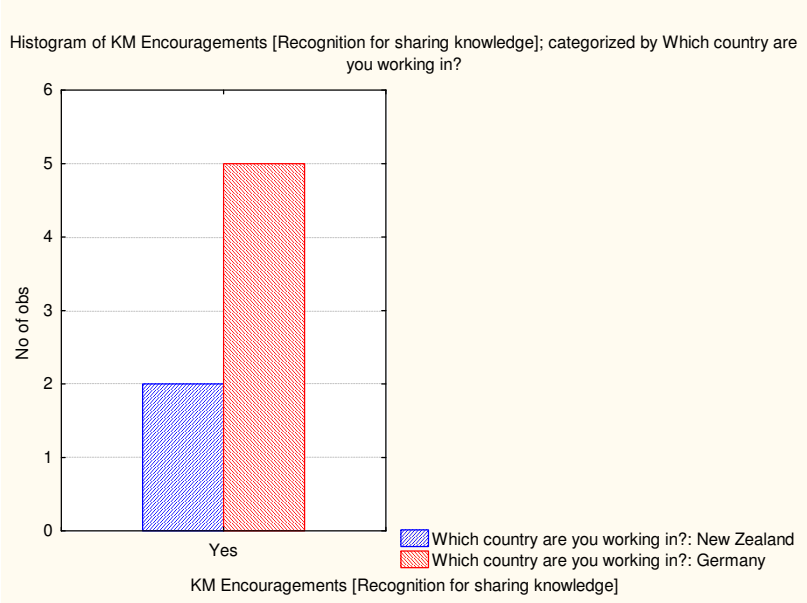


Figure 71

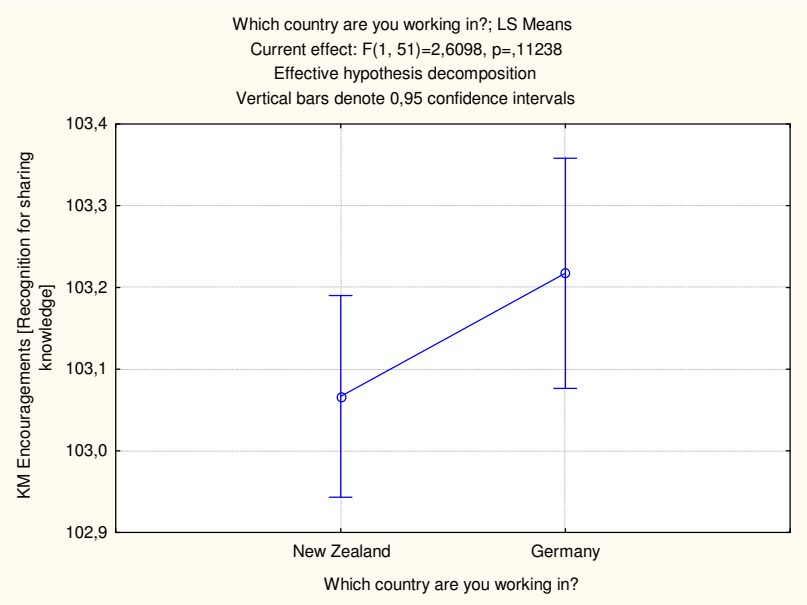


Figure 72

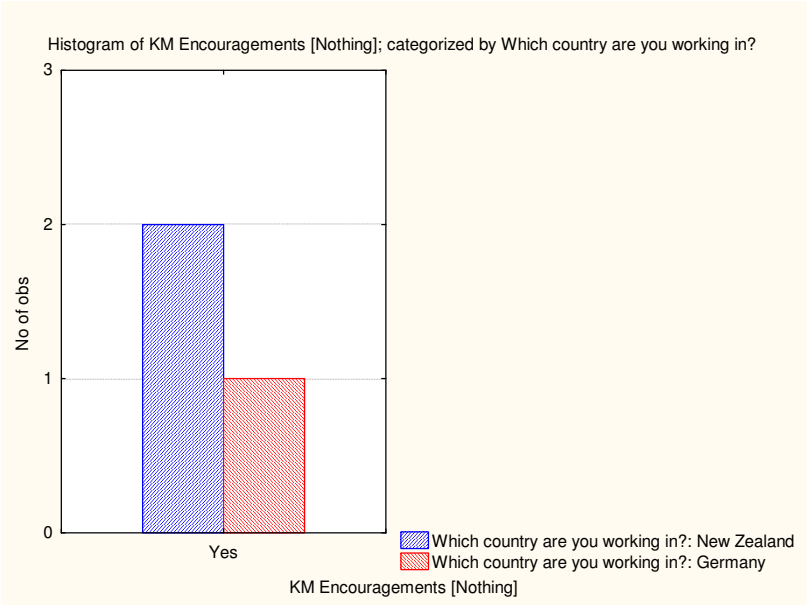


Figure 73

4.1.2 Association with KM success

The results showed that companies with a moderate knowledge management success could be associated with the support of a communicative work climate, see *Figure 74*. Companies with a great knowledge management success do not only support a communicative work climate, but also actively encourage their employees to present ideas and knowledge and set up regular meetings for knowledge exchange. Also an association *between* these three different methods could be found.

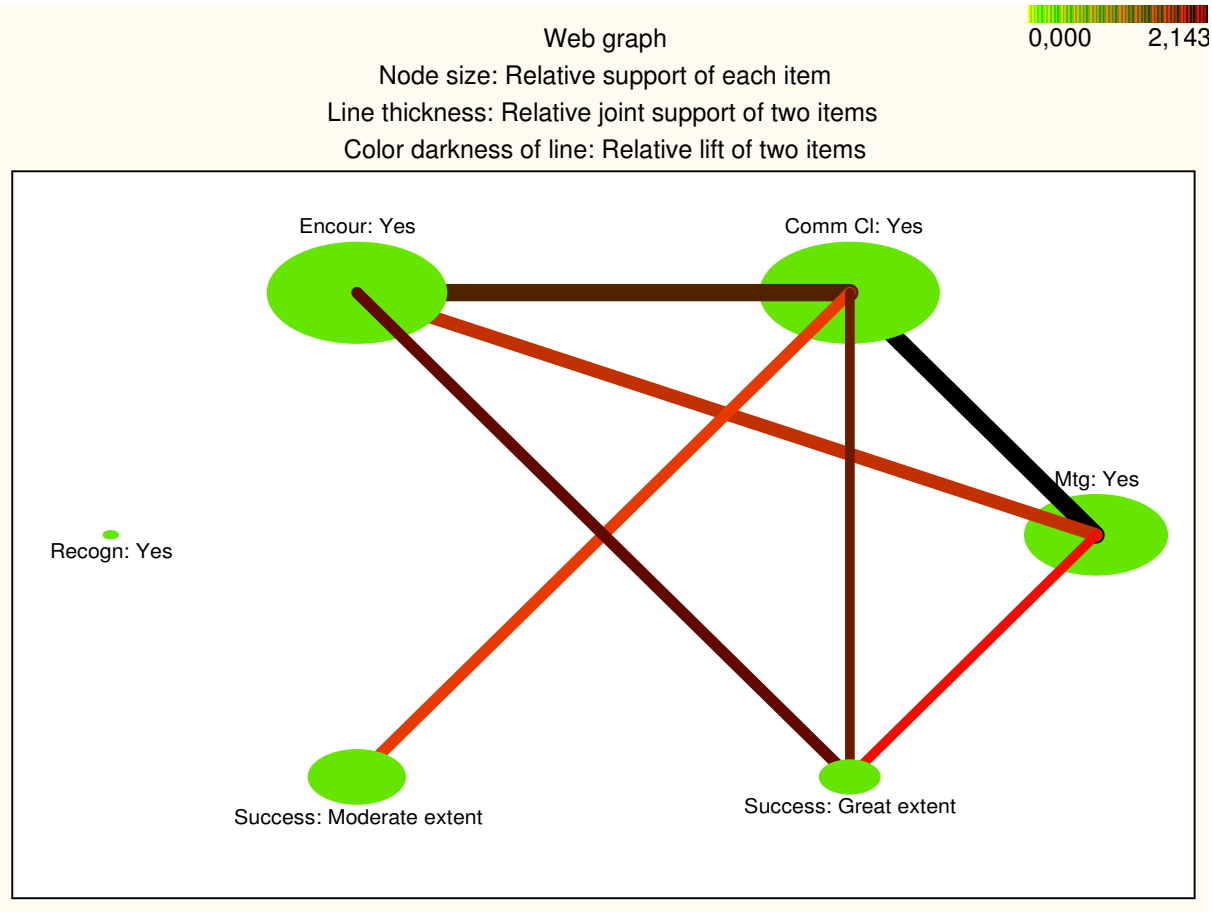


Figure 74: SAL results for staff encouragement methods vs KM success. Support min 0.15, confidence 0.15.

Summary of association rules (University of Canterbury Resear in Workbook_1.09.stw) Min: support = 15,0%, confidence = 15,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence (%)	Lift
1	Success: Great extent	==>	Mtg: Yes	14,86486	68,75000	2,035000
2	Mtg: Yes	==>	Success: Great extent	14,86486	44,00000	2,035000
3	Encour: Yes	==>	Mtg: Yes	22,97297	58,62069	1,735172
4	Mtg: Yes	==>	Encour: Yes	22,97297	68,00000	1,735172
5	Encour: Yes	==>	Mtg: Yes, Comm Cl: Yes	21,62162	55,17241	1,944171
6	Comm Cl: Yes	==>	Mtg: Yes, Encour: Yes	21,62162	55,17241	2,401623
7	Comm Cl: Yes, Encour: Yes	==>	Mtg: Yes	21,62162	76,19048	2,255238
8	Mtg: Yes	==>	Comm Cl: Yes, Encour: Yes	21,62162	64,00000	2,255238

9	Mtg: Yes, Encour: Yes	==>	Comm Cl: Yes	21,62162	94,11765	2,401623
10	Mtg: Yes, Comm Cl: Yes	==>	Encour: Yes	21,62162	76,19048	1,944171
11	Comm Cl: Yes	==>	Mtg: Yes	28,37838	72,41379	2,143448
12	Mtg: Yes	==>	Comm Cl: Yes	28,37838	84,00000	2,143448
13	Success: Great extent	==>	Comm Cl: Yes	16,21622	75,00000	1,913793
14	Comm Cl: Yes	==>	Success: Great extent	16,21622	41,37931	1,913793
15	Success: Great extent	==>	Comm Cl: Yes, Encour: Yes	14,86486	68,75000	2,422619
16	Encour: Yes	==>	Comm Cl: Yes, Success: Great extent	14,86486	37,93103	2,339080
17	Encour: Yes, Success: Great extent	==>	Comm Cl: Yes	14,86486	84,61538	2,159151
18	Comm Cl: Yes	==>	Encour: Yes, Success: Great extent	14,86486	37,93103	2,159151
19	Comm Cl: Yes, Success: Great extent	==>	Encour: Yes	14,86486	91,66667	2,339080
20	Comm Cl: Yes, Encour: Yes	==>	Success: Great extent	14,86486	52,38095	2,422619
21	Success: Moderate extent	==>	Comm Cl: Yes	17,56757	65,00000	1,658621
22	Comm Cl: Yes	==>	Success: Moderate extent	17,56757	44,82759	1,658621
23	Encour: Yes	==>	Comm Cl: Yes	28,37838	72,41379	1,847800
24	Comm Cl: Yes	==>	Encour: Yes	28,37838	72,41379	1,847800
25	Success: Great extent	==>	Encour: Yes	17,56757	81,25000	2,073276
26	Encour: Yes	==>	Success: Great extent	17,56757	44,82759	2,073276

Figure 75

4.1.3 Association with own willingness to share

SAL showed that a great willingness to share knowledge can be associated with a communicative work climate, regular meetings and active encouragement to share knowledge, see *Figure 76*.

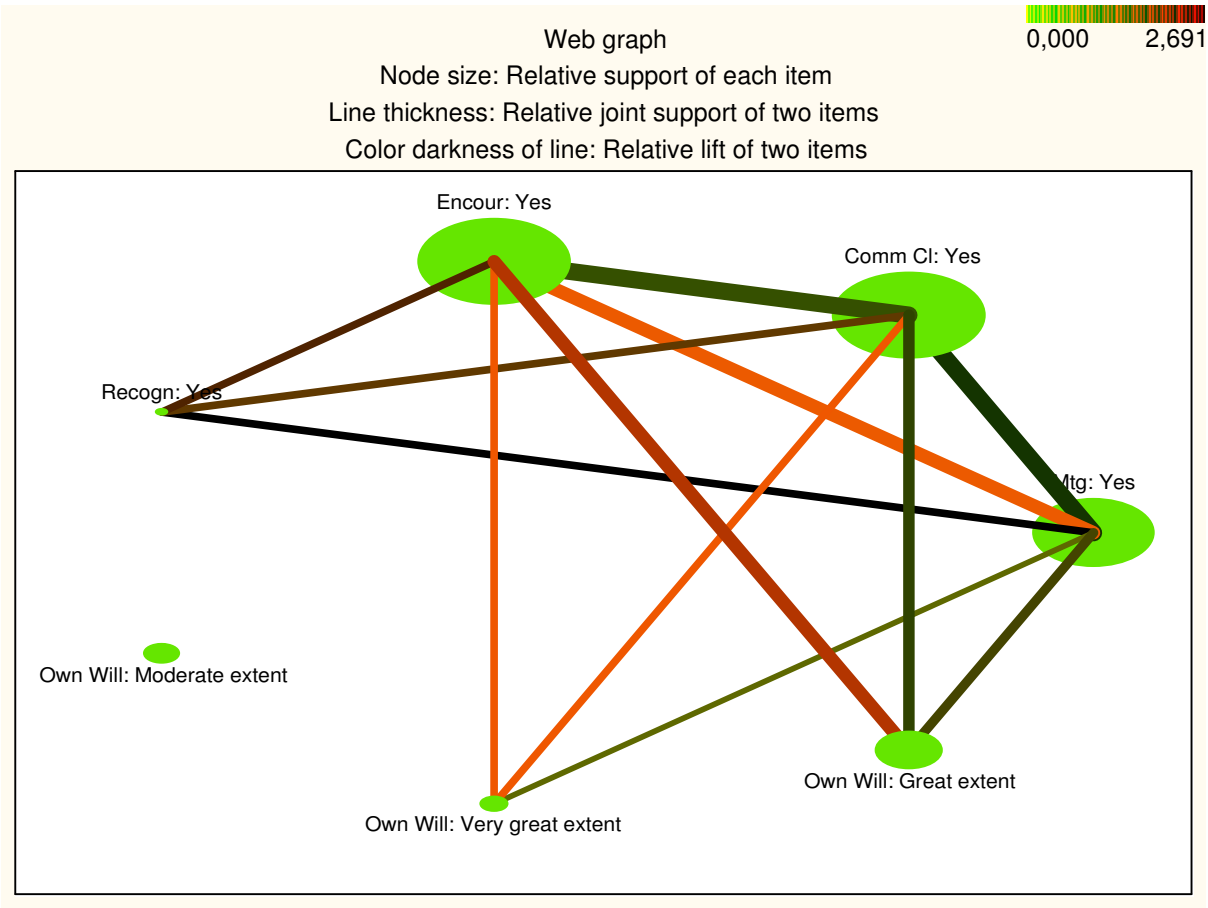


Figure 76: SAL results for own willingness to share knowledge vs encouragement methods of firms

Summary of association rules (University of Canterbury Resear in Workbook_1.09.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence (%)	Lift
1	Own Will: Great extent	==>	Mtg: Yes	16,21622	66,6667	1,973333
2	Mtg: Yes	==>	Own Will: Great extent	16,21622	48,0000	1,973333
3	Own Will: Great extent	==>	Mtg: Yes, Encour: Yes	12,16216	50,0000	2,176471
4	Encour: Yes	==>	Mtg: Yes, Own Will: Great extent	12,16216	31,0345	1,913793
5	Encour: Yes, Own Will: Great extent	==>	Mtg: Yes	12,16216	60,0000	1,776000
6	Mtg: Yes	==>	Encour: Yes, Own Will: Great extent	12,16216	36,0000	1,776000

7	Mtg: Yes, Own Will: Great extent	==>	Encour: Yes	12,16216	75,0000	1,913793
8	Mtg: Yes, Encour: Yes	==>	Own Will: Great extent	12,16216	52,9412	2,176471
9	Own Will: Great extent	==>	Mtg: Yes, Comm Cl: Yes	13,51351	55,5556	1,957672
10	Comm Cl: Yes	==>	Mtg: Yes, Own Will: Great extent	13,51351	34,4828	2,126437
11	Comm Cl: Yes, Own Will: Great extent	==>	Mtg: Yes	13,51351	71,4286	2,114286
12	Mtg: Yes	==>	Comm Cl: Yes, Own Will: Great extent	13,51351	40,0000	2,114286
13	Mtg: Yes, Own Will: Great extent	==>	Comm Cl: Yes	13,51351	83,3333	2,126437
14	Mtg: Yes, Comm Cl: Yes	==>	Own Will: Great extent	13,51351	47,6190	1,957672

Figure 77

4.2 How would you rate your own willingness to share knowledge within the company?

On the whole most survey respondents rated their willingness to share their knowledge within their company as high (67% great to very great extent), see *Figure 78*.

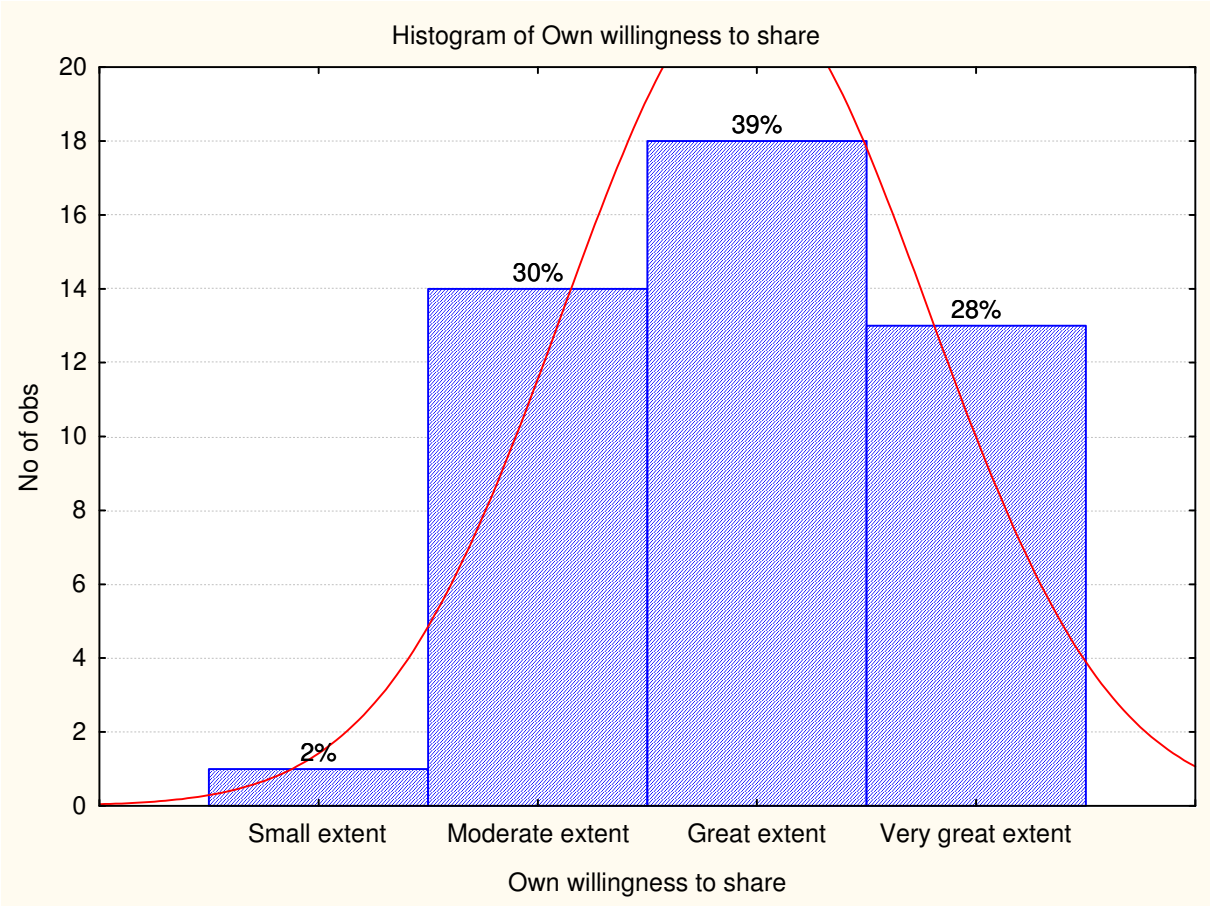


Figure 78

4.2.1 Comparison between New Zealand and Germany

The results show that there are no significant differences between New Zealand and Germany, see *Figure 79*. While New Zealanders are slightly more positive (very great extent), there are more Germans rating their willingness to share their knowledge high (great extent).

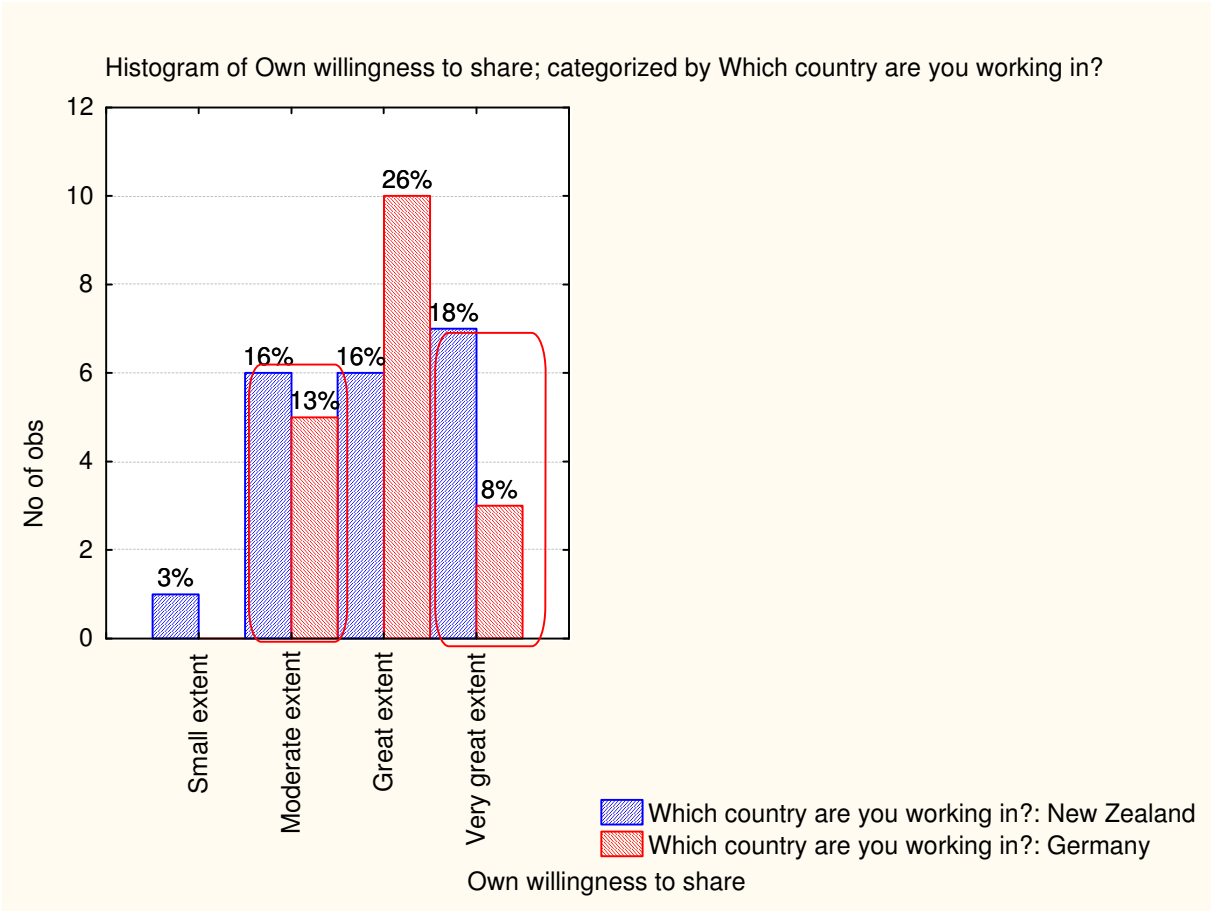

Histogram of Own willingness to share; categorized by Which country are you working in?
No of obs
12
10
8
6
4
2
0
3%
16%
13%
16%
26%
18%
8%
Small extent
Moderate extent
Great extent
Very great extent
Which country are you working in?: New Zealand
Which country are you working in?: Germany
Own willingness to share

Figure 79

4.2.2 Association with organisational culture

The SAL showed that a great personal willingness to share is associated with an adequate to good organisational culture, see *Figure 80*.

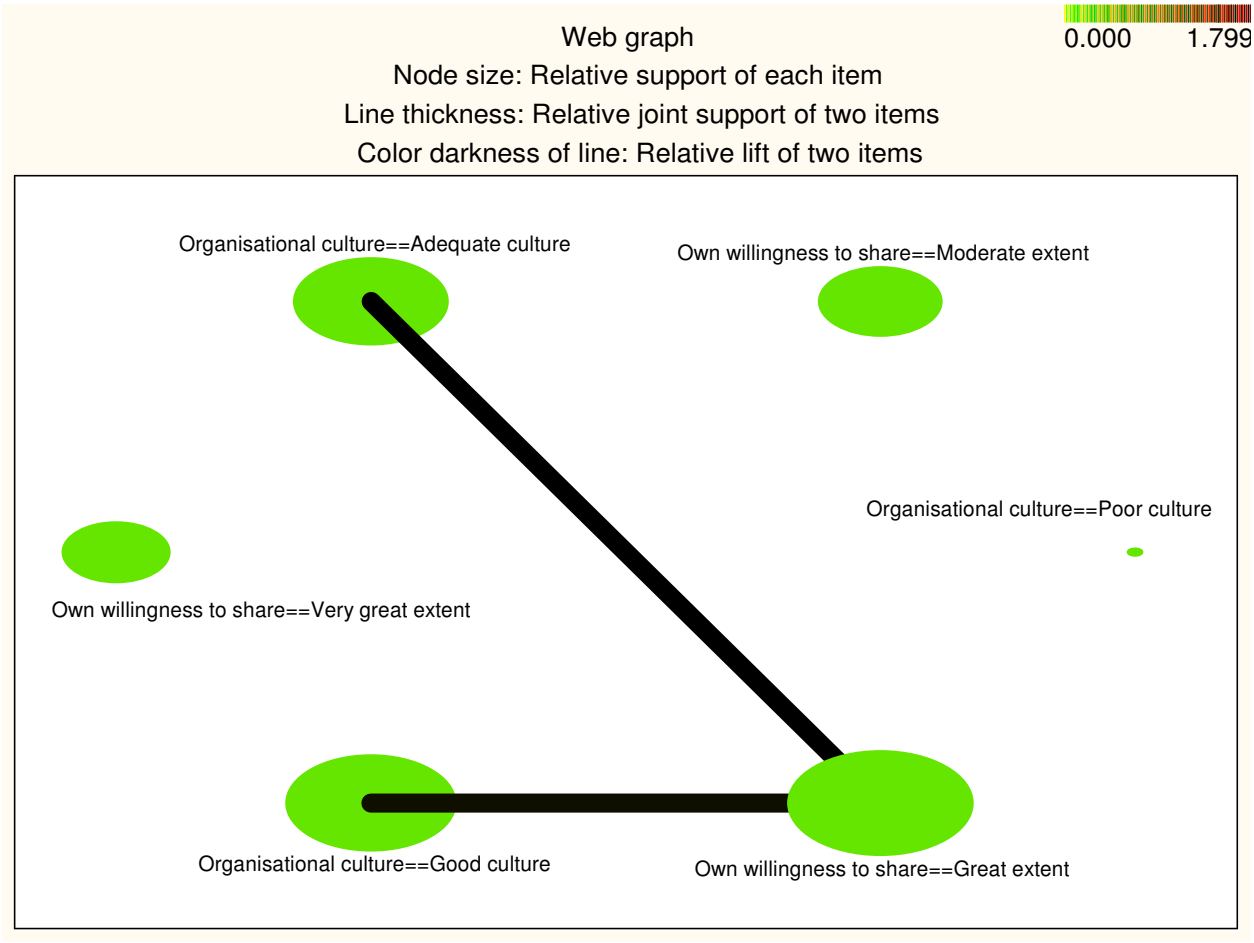


Figure 80: SAL for own willingness to share knowledge and organisational culture, min support 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.04.stw) Min: support = 10.0%, confidence = 10.0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Own willingness to share==Great extent	==>	Organisational culture==Adequate culture	9.459459	38.88889	1.798611
2	Organisational culture==Adequate culture	==>	Own willingness to share==Great extent	9.459459	43.75000	1.798611
3	Own willingness to share==Great extent	==>	Organisational culture==Good culture	9.459459	38.88889	1.692810

4	Organisational culture==Good culture	== >	Own willingness to share==Great extent	9.459459	41.17647	1.692810

Figure 81

It is interesting that even an 'adequate' culture is sufficient for a 'great' willingness to share. What this suggests is that there may be thresholds for sharing. This was further explored by using a box plot (assuming a numerical ordered scale to the variable for willingness to share), see *Figure 82*.

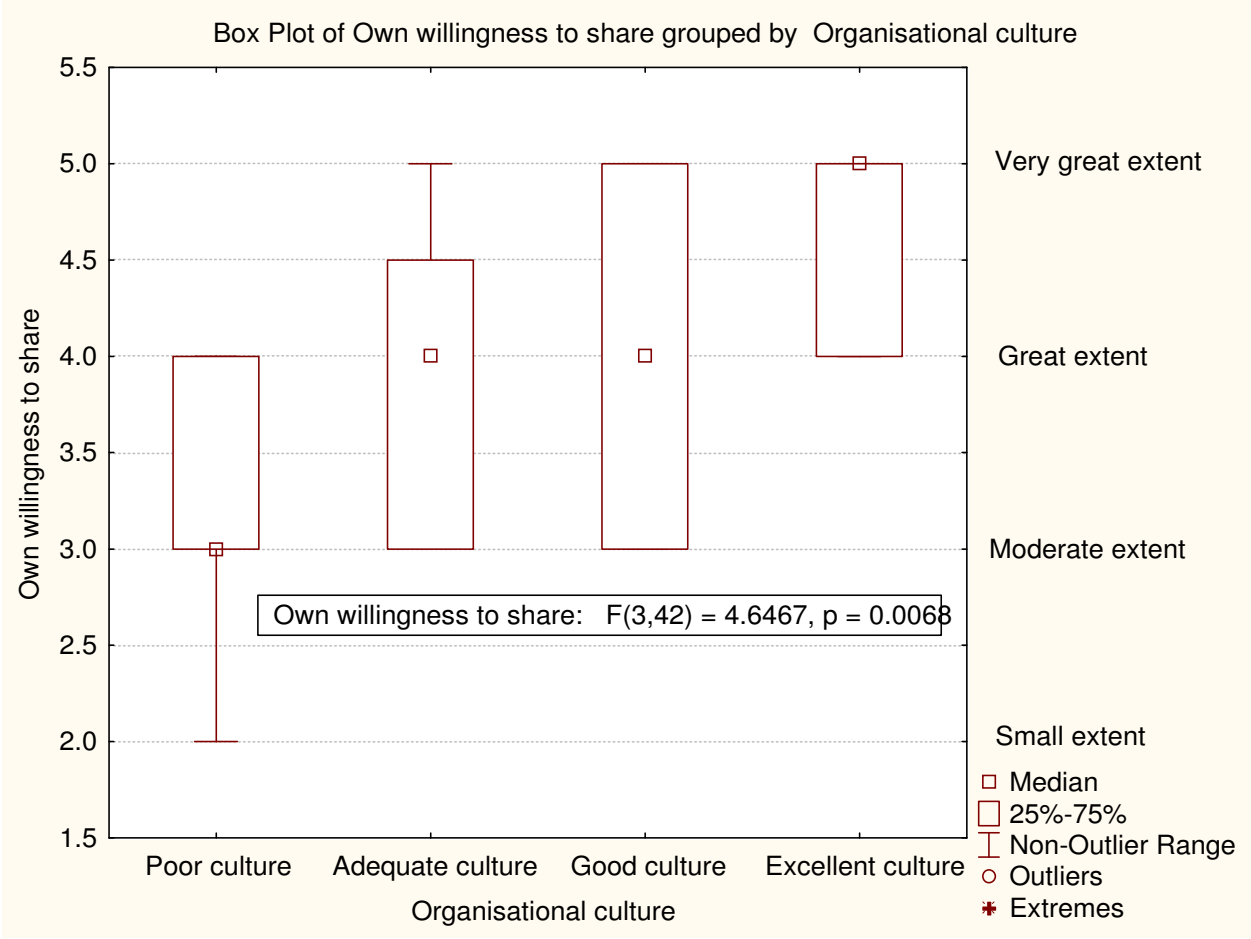


Figure 82: Box plot for willingness to share plotted against organisational culture.

The results show that there is indeed a relationship. The ANOVA test showed that there is a significant difference (p=0.0068) in willingness to share across different organisational cultures. The relationship is one of increasing willingness to share with improved organisational culture. The effect is approximately linear, or at least monotonically upwards. It is interesting to note that even in poor cultures the willingness to share is still there to some extent.

4.3 What factors make it difficult for you to share your knowledge?

By far the most important difficulty regarding knowledge sharing is a lack of time.

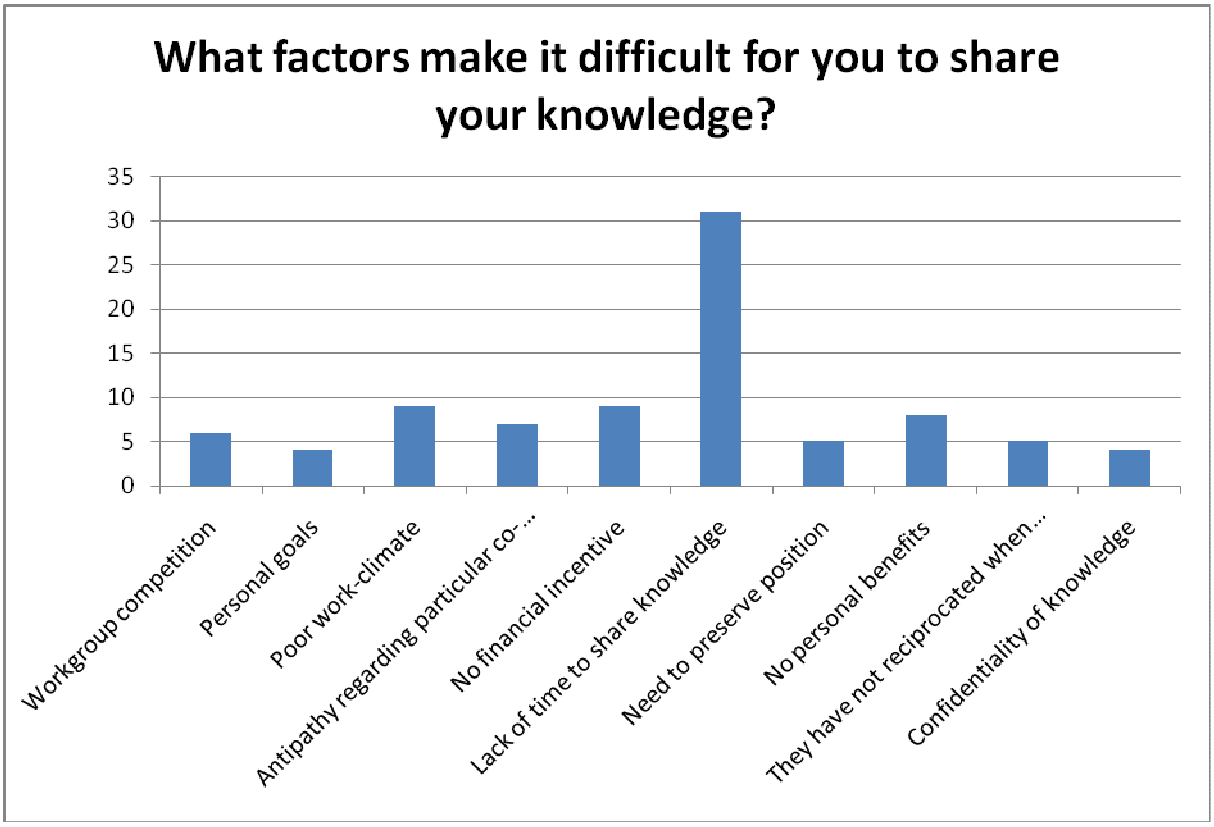


Figure 83

4.3.1 Comparison between New Zealand and Germany

Since a lack of time was the only significant problem regarding knowledge sharing, only the potential variation of this particular result was explored. However, no difference was found, see *Figure 84*.

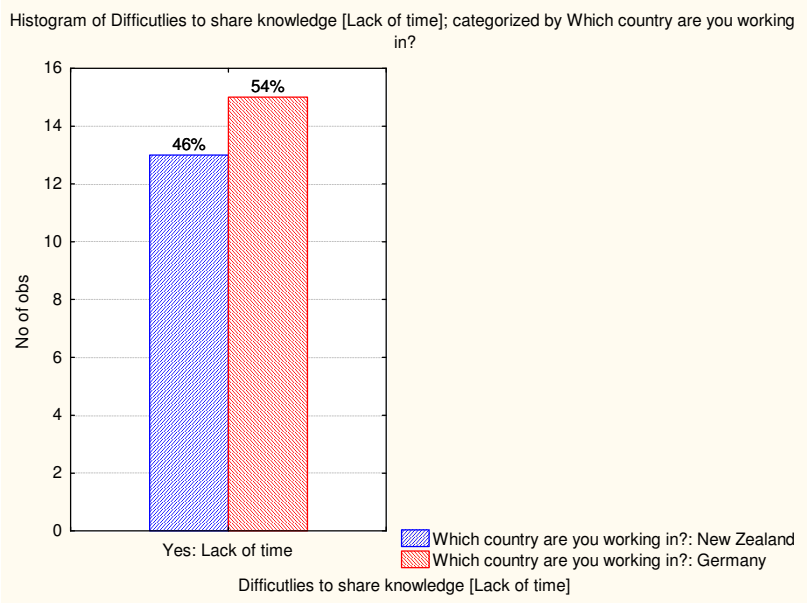


Figure 84

4.4 What factors generally increase (or would increase) your motivation to share knowledge?

Survey respondents thought that rewards or even recognition for sharing knowledge would increase their motivation to do so. Also a good work-climate was mentioned as beneficial.

4.5 How would you rate your willingness to ask questions in order to acquire knowledge?

Figure 85

4.5.1 Comparison between New Zealand and Germany

On the whole respondents in New Zealand were more positive regarding their willingness to ask questions to acquire knowledge than respondents in Germany, see *Figure 86*. The ANOVA result (p=0.01) showed that the difference is statistically significant, see *Figure 87*.

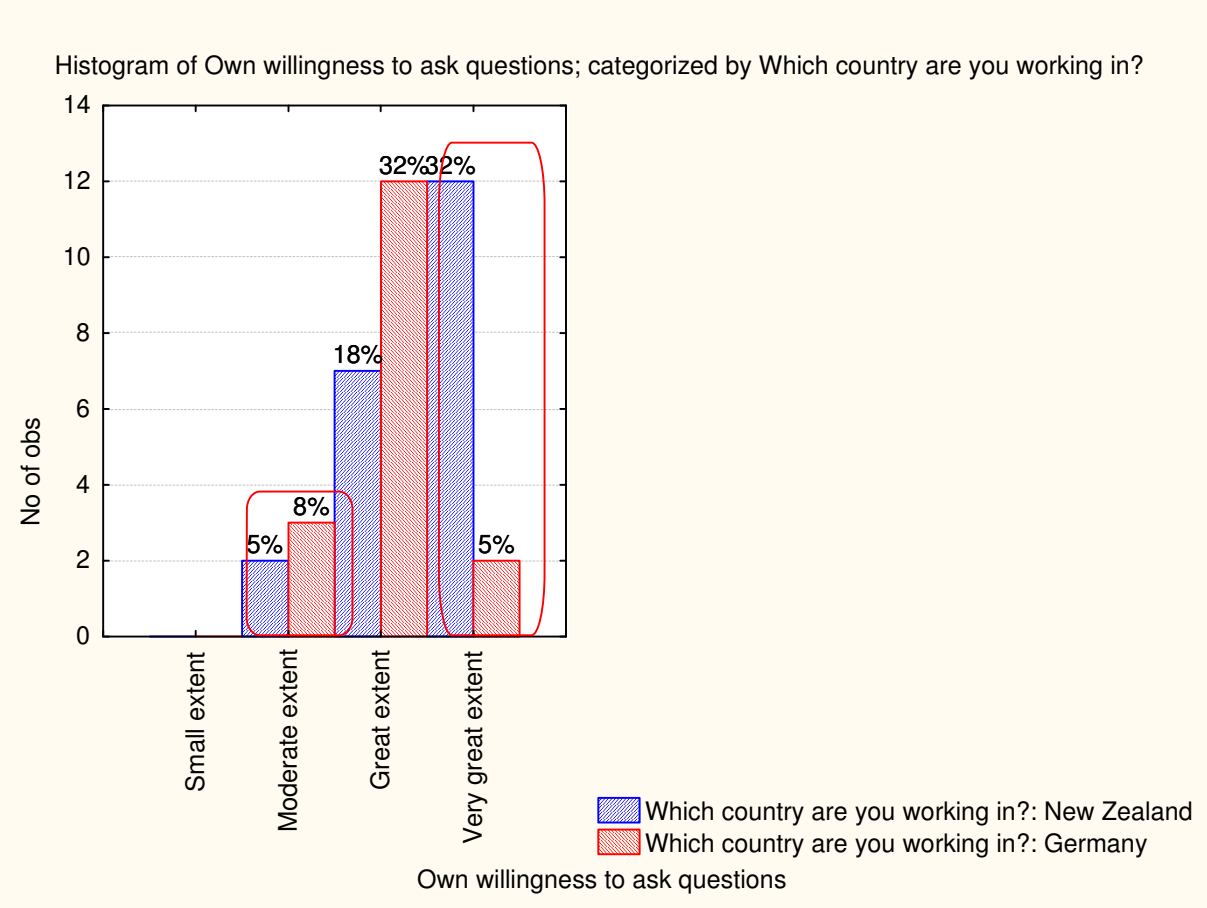


Figure 86

Figure 87 shows that the difference between companies in New Zealand and companies in Germany regarding the willingness to ask questions to acquire knowledge is statistically significant (ANOVA p=0,01).

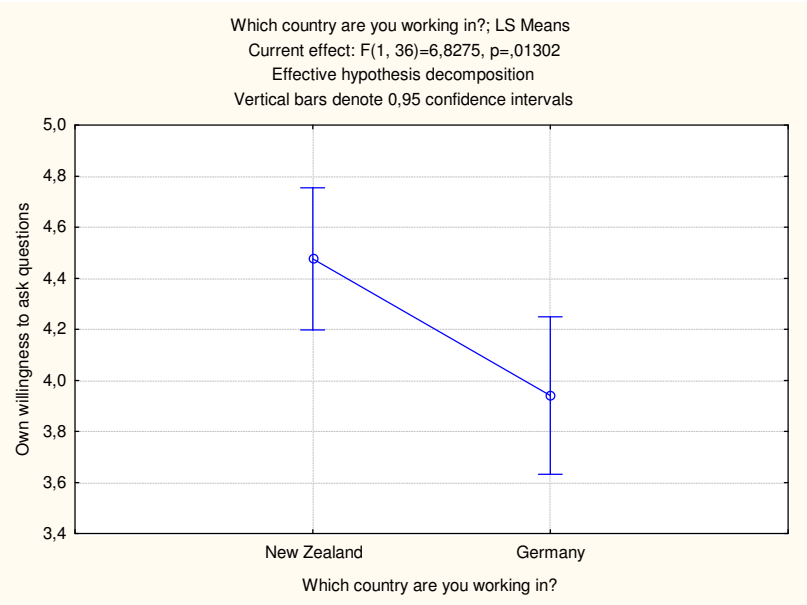


Figure 87

4.5.2 Association with organisational culture

When examining the variables of organisational culture (work-climate) and willingness to ask questions, the SAL showed that an adequate culture is associated with a great willingness, and a good culture with a very great willingness, see *Figure 88*.

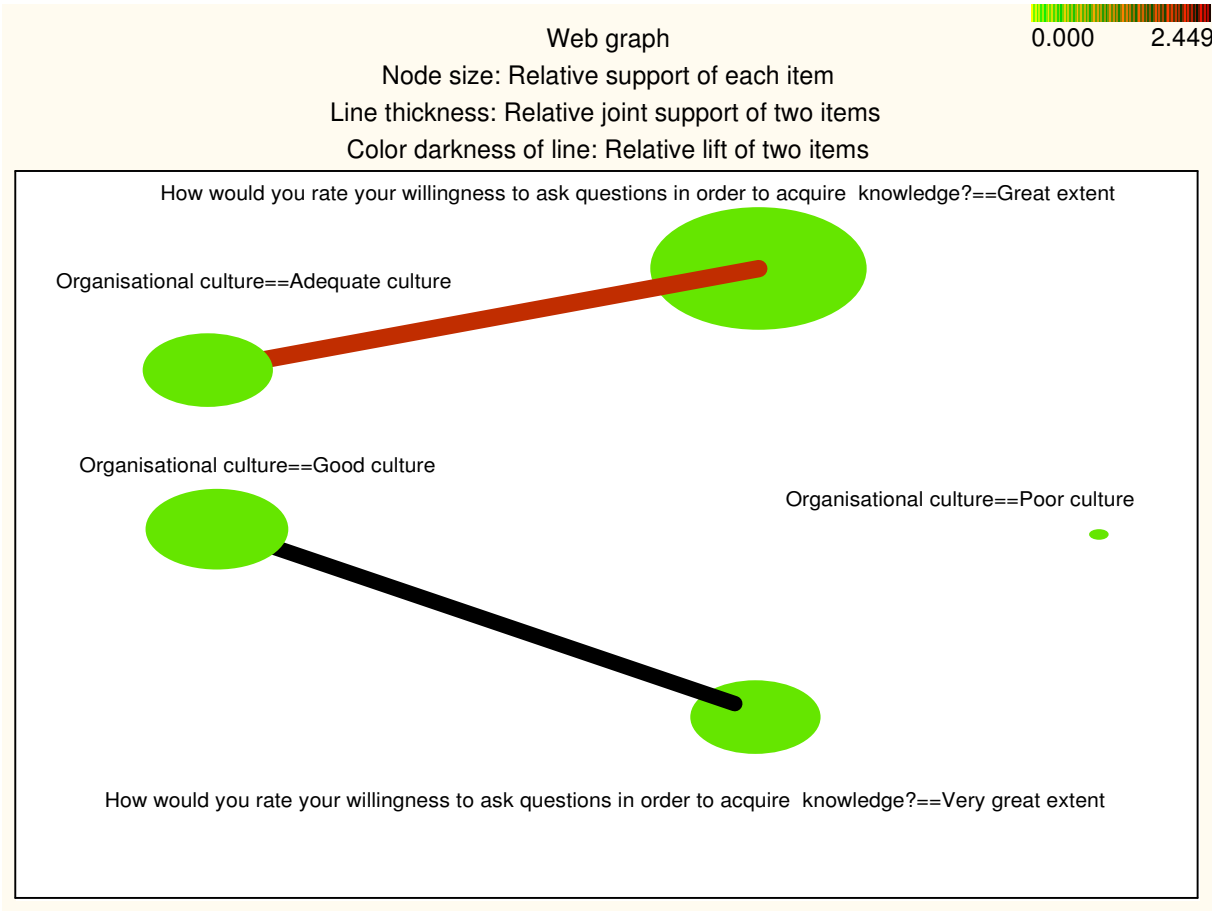


Figure 88: SAL results for willingness to ask vs organisational culture. Support min 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.04.stw) Min: support = 10.0%, confidence = 10.0% Max. size of an itemset = 10

	Body	==>	Head	Support (%)	Confidence(%)	Lift
1	Organisational culture==Adequate culture	==>	How would you rate your willingness to ask questions in order to acquire knowledge?==Great extent	13.5135	62.5000	2.01087
2	How would you rate your willingness to ask questions in order to acquire	==	Organisational culture==Adequate culture	13.5135	43.4782	2.01087

	knowledge?==Great extent	>		1		0
3	Organisational culture==Good culture	==>	How would you rate your willingness to ask questions in order to acquire knowledge?==Very great extent	12.1621 6	52.94118	2.448529
4	How would you rate your willingness to ask questions in order to acquire knowledge?==Very great extent	==>	Organisational culture==Good culture	12.1621 6	56.25000	2.448529

Figure 89

Although the SAL found an association between specific answers in the two variables, there is no relationship overall, as *Figure 90* shows.

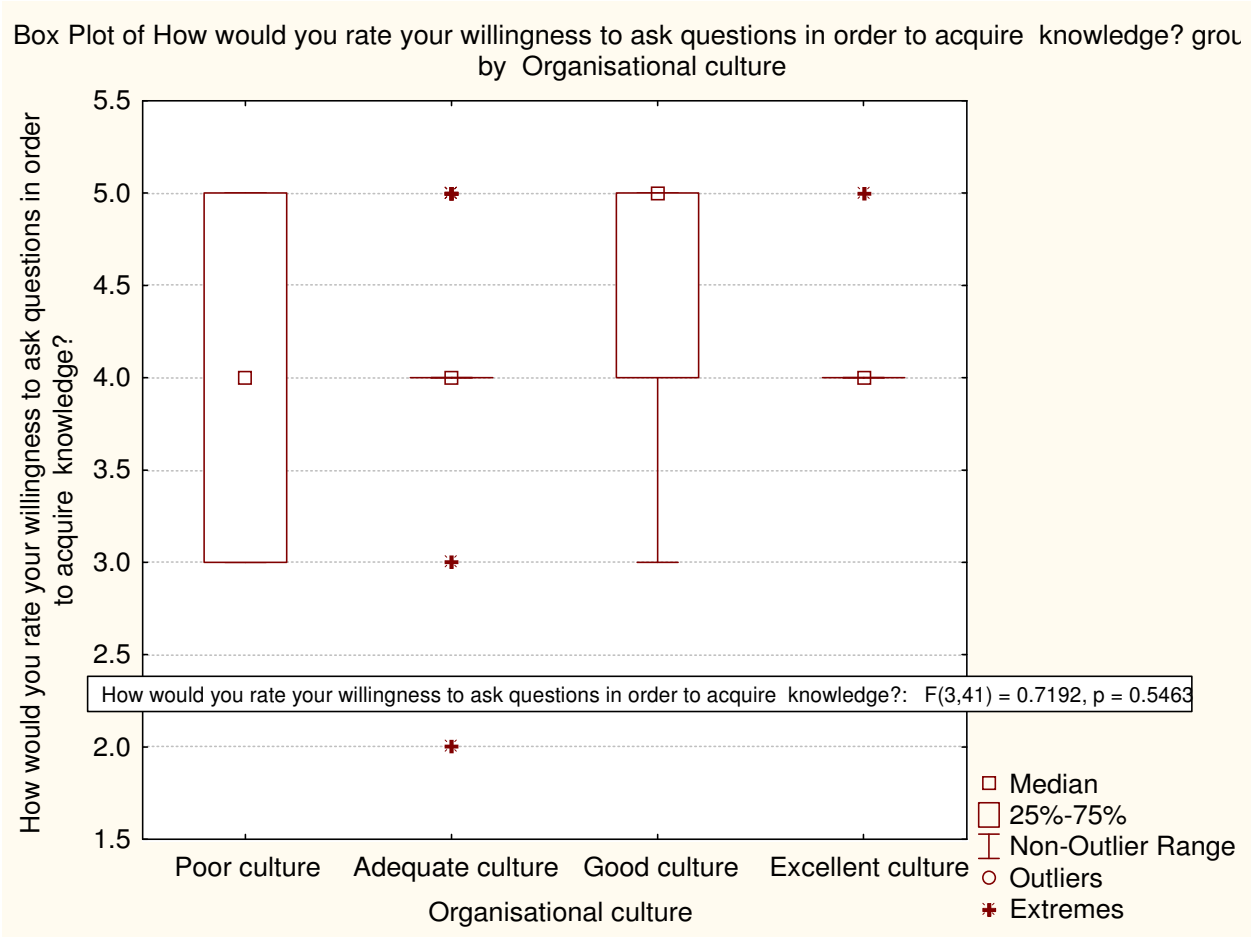


Figure 90: Boxplot for willingness to ask questions vs. Organisational culture

Although there is a upward trend (see *Figure 90*), the results are not statistically significant (p=0.54). So we conclude from this that willingness to ask questions is not nesseccarily associated with the work-climate.

4.5.3 Association with the own willingness to share knowledge

SAL showed that a great willingness to ask questions can be associated with a great and a moderate willingness to share own knowledge, see *Figure 91*. It is interesting to see that people with only a moderate willingness to share their own knowledge can still be associated with a great willingness to ask questions to acquire knowledge. Also an association between a very great willingness to ask questions and a very great willingness to share own knowledge can be found.

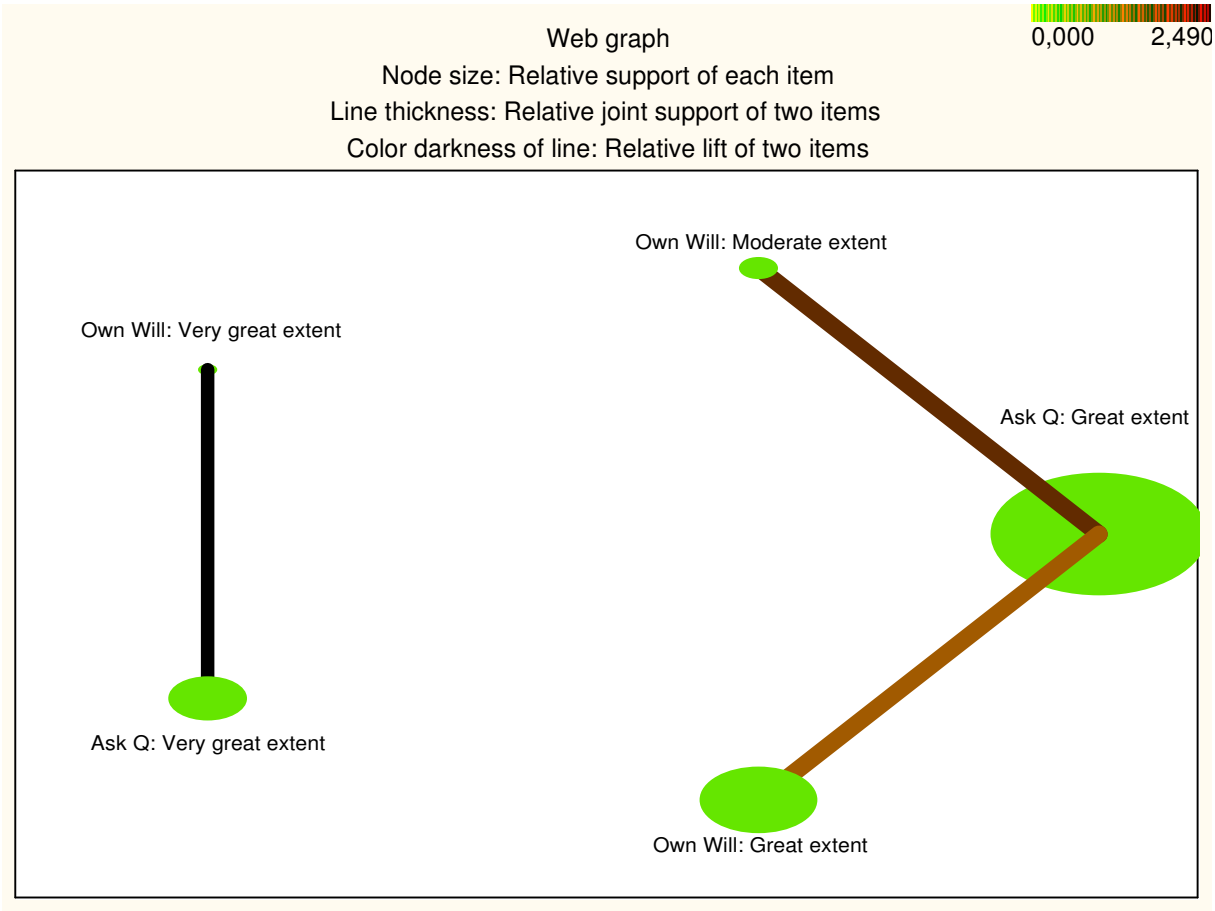


Figure 91: SAL for willingness to ask vs. own willingness to share. Min support 0.1, confidence 0.1.

Summary of association rules (University of Canterbury Resear in Workbook_1.09.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Own Will: Great extent	==>	Ask Q: Great extent	12,16216	50,00000	1,608696
2	Ask Q: Great extent	==>	Own Will: Great extent	12,16216	39,13043	1,60869

						6
3	Own Will: Moderate extent	==>	Ask Q: Great extent	12,16216	64,28571	2,068323
4	Ask Q: Great extent	==>	Own Will: Moderate extent	12,16216	39,13043	2,068323
5	Ask Q: Very great extent	==>	Own Will: Very great extent	9,45946	43,75000	2,490385
6	Own Will: Very great extent	==>	Ask Q: Very great extent	9,45946	53,84615	2,490385

Figure 92

4.5.4 Association with the willingness of co-workers to share knowledge

A great willingness to ask questions to acquire knowledge can be associated with a great willingness of co-workers to share their knowledge. However, an association with a moderate willingness of co-workers to share and a great own willingness to ask questions can still be found, see *Figure 93*.

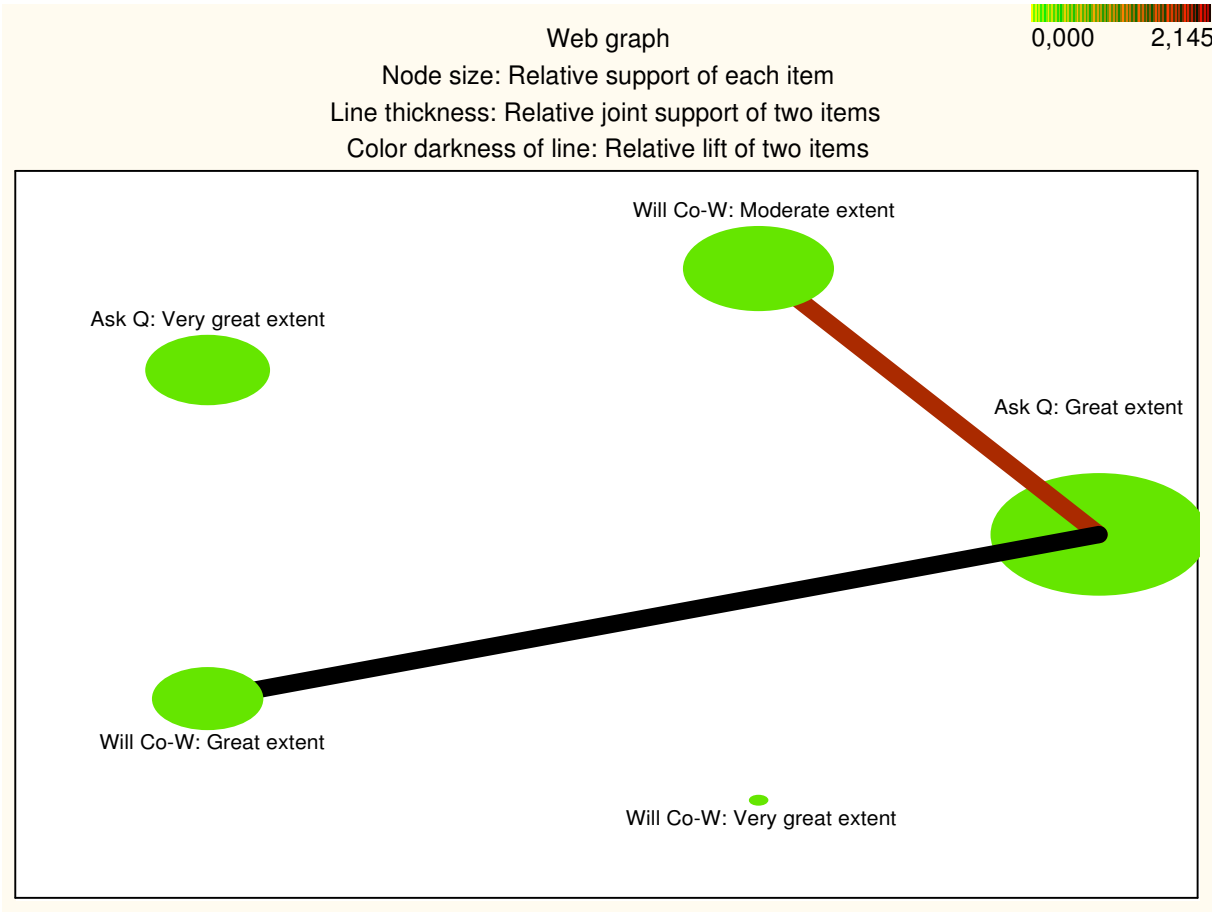


Figure 93: SAL for willing to ask vs. willingness of co-workers to share. Min support 0.1, confidence 0.1.

Will Co-W: Great extent	==>	Ask Q: Great extent	13,51351	66,66667	2,144928
Ask Q: Great extent	==>	Will Co-W: Great extent	13,51351	43,47826	2,144928
Will Co-W: Moderate extent	==>	Ask Q: Great extent	13,51351	55,55556	1,787440
Ask Q: Great extent	==>	Will Co-W: Moderate extent	13,51351	43,47826	1,787440

Figure 94

4.5.5 Association with own openness

SAL showed an association between a great willingness to ask questions and a great openness. But even a moderate openness can be associated with a great willingness to ask questions, see *Figue 95.*

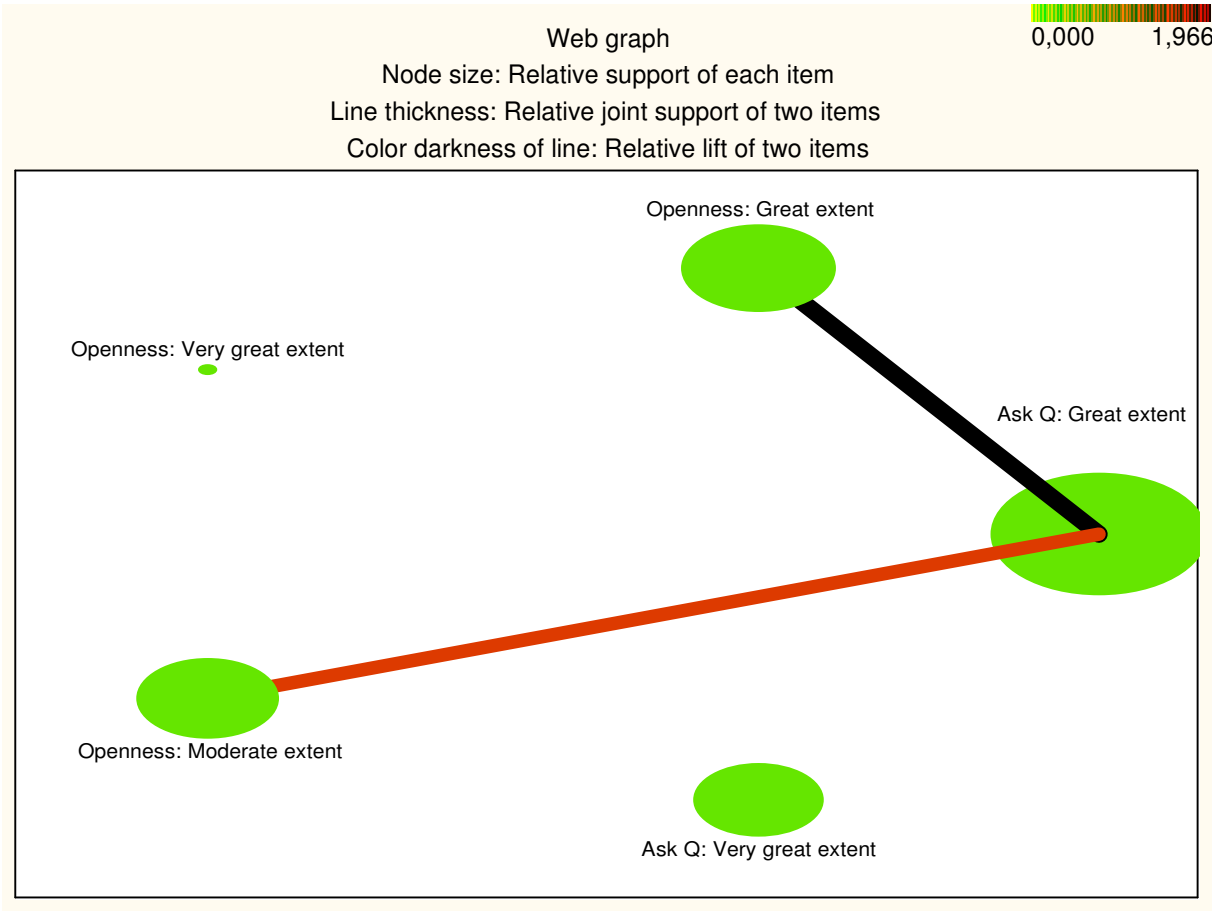


Figure 95: SAL for willingness to ask and openness. Min support 0.1, confidence 0.1.

Summary of association rules (University of Canterbury Resear in Workbook_1.10.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Openness: Moderate extent	==>	Ask Q: Great extent	10,81081	47,05882	1,514066
2	Ask Q: Great extent	==>	Openness: Moderate extent	10,81081	34,78261	1,514066

3	Openness: Great extent	==>	Ask Q: Great extent	14,86486	61,11111	1,966184
4	Ask Q: Great extent	==>	Openness: Great extent	14,86486	47,82609	1,966184

Figure 96

4.5.6 Association with own extraversion

A great willingness to ask questions could be associated with a moderate degree of extraversion. Also there is an association between a moderate degree of extraversion and a very great willingness to ask questions, see *Figure 97*.

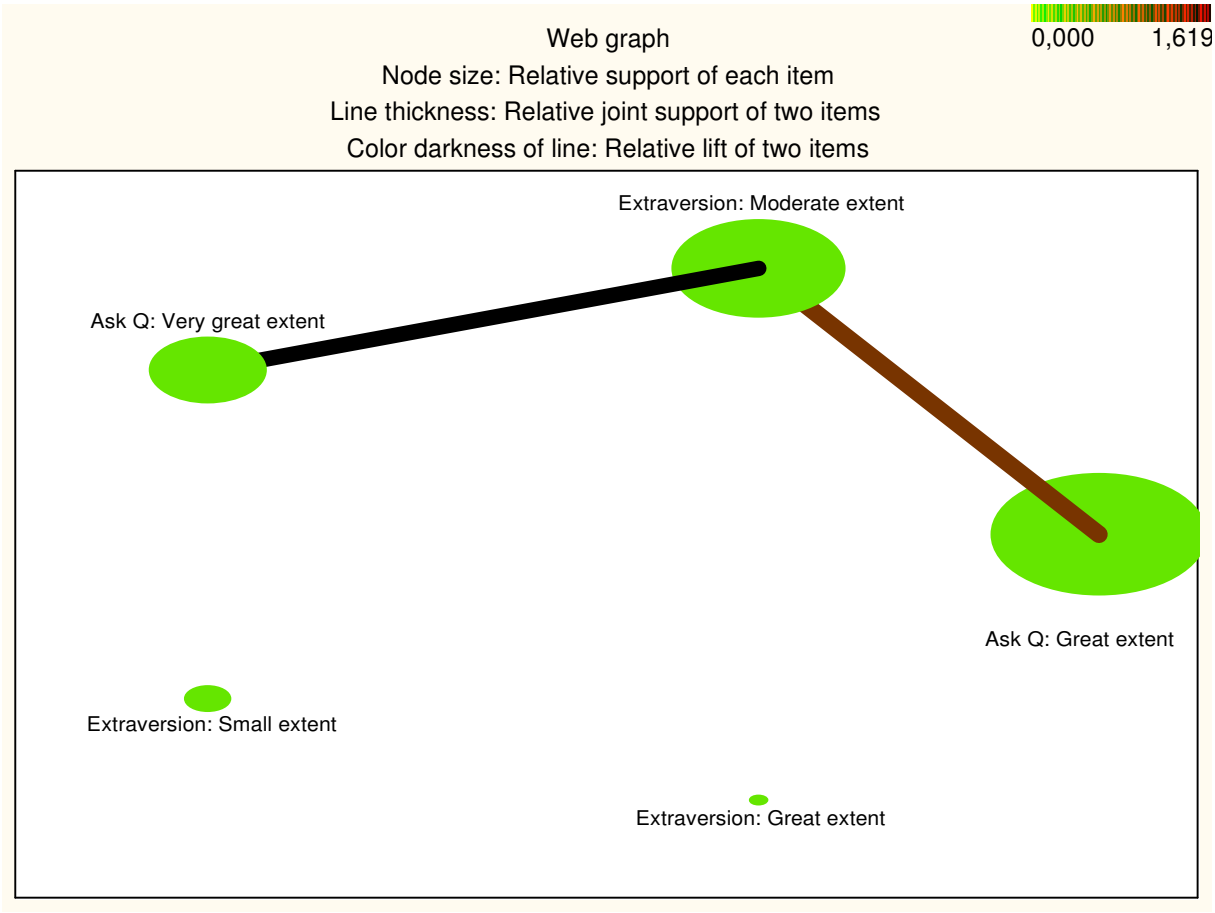


Figure 97: SAL for willingness to ask and extraversion. Min support 0.1, confidence 0.1.

Summary of association rules (University of Canterbury Resear in Workbook_1.10.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10						
	Body	**==>**	**Head**	**Support(%)**	**Confidence(%)**	**Lift**
1	Extraversion: Moderate	==	Ask Q: Great extent	10,81081	40,00000	1,28695

	extent	>				7
2	Ask Q: Great extent	==>	Extraversion: Moderate extent	10,81081	34,78261	1,286957
3	Ask Q: Very great extent	==>	Extraversion: Moderate extent	9,45946	43,75000	1,618750
4	Extraversion: Moderate extent	==>	Ask Q: Very great extent	9,45946	35,00000	1,618750

Figure 98

4.6 How would you rate the willingness of your co-workers to share knowledge within the company?

Most survey respondents found that their co-workers were willing to share their knowledge to a moderate extent. However, more than half of the respondents rated the willingness of their co-workers to share their knowledge was high (52% great to very great extent), see*Figure 99*.

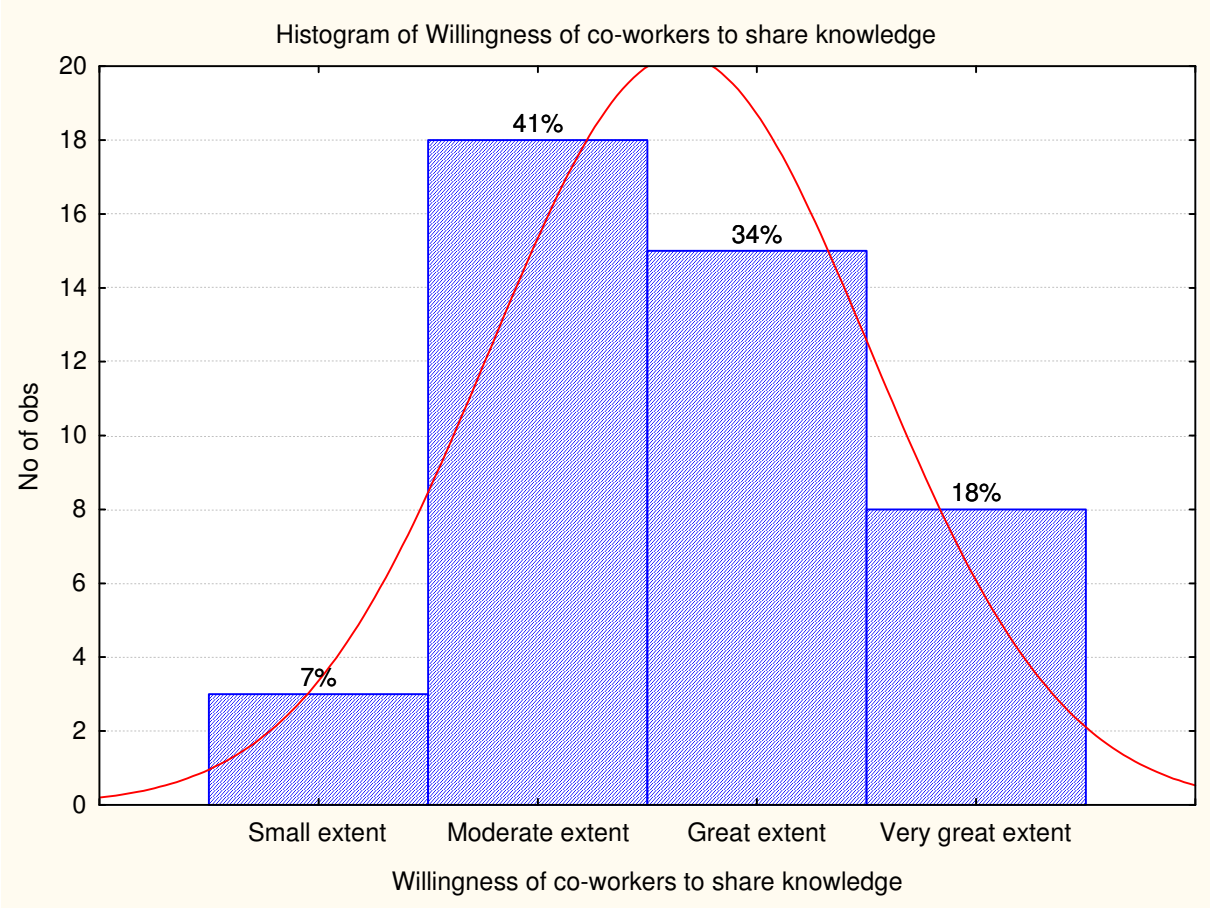


Figure 99

4.6.1 Comparison between New Zealand and Germany

Figure 100 shows that New Zealanders tended to be more positive regarding the willingness of co-workers to share their knowledge. But these results proved to be not statistically significant (ANOVA p=0,45), see *Figure 101*.

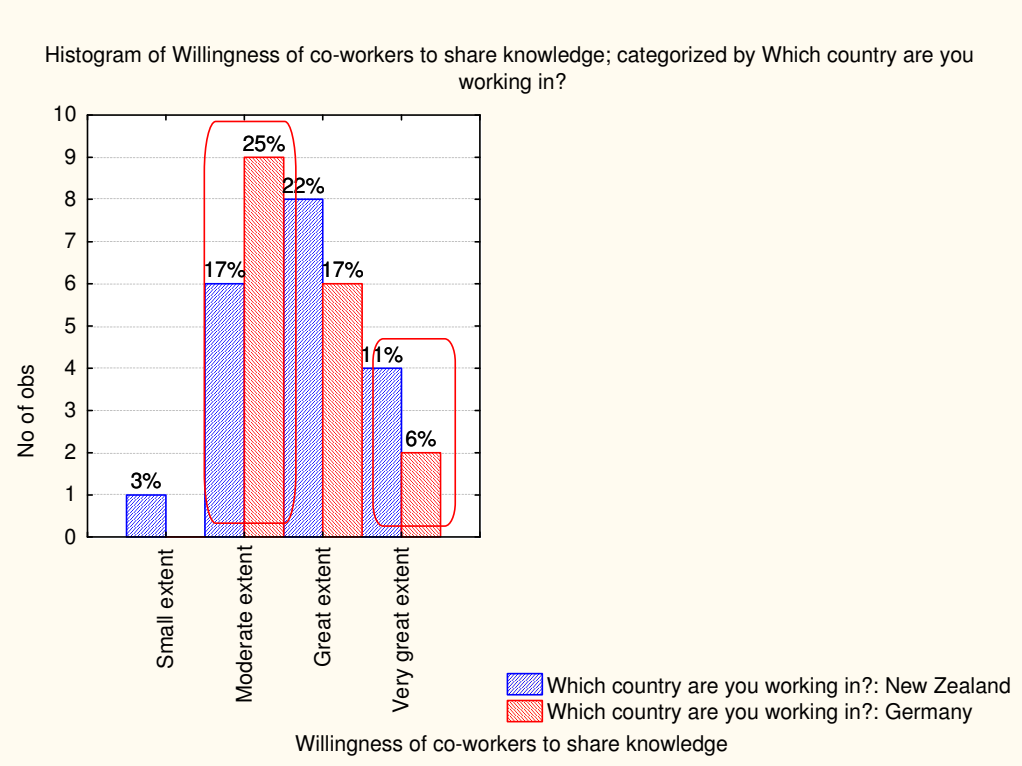


Figure 100

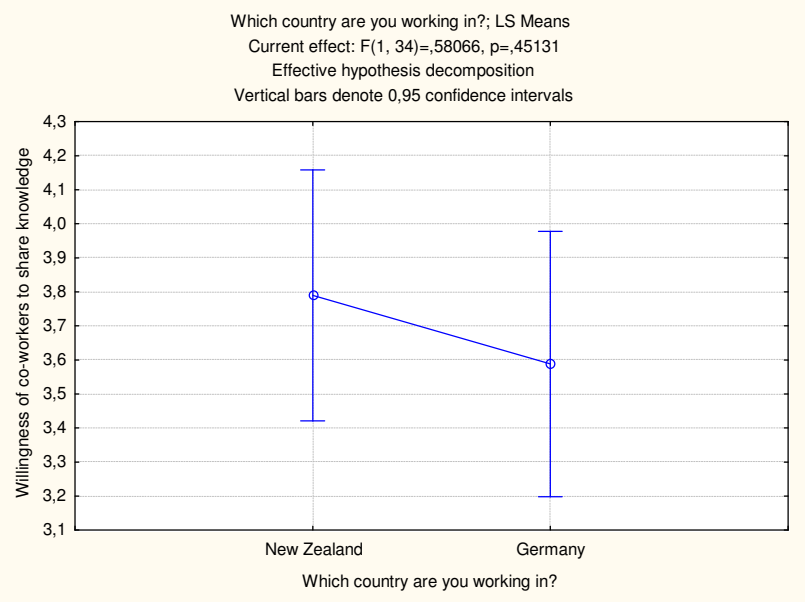


Figure 101

4.6.2 Association with the organisational culture

SAL showed no association between the willingness of co-workers to share information and the organisational culture (work-climate), see *Figure 102*.

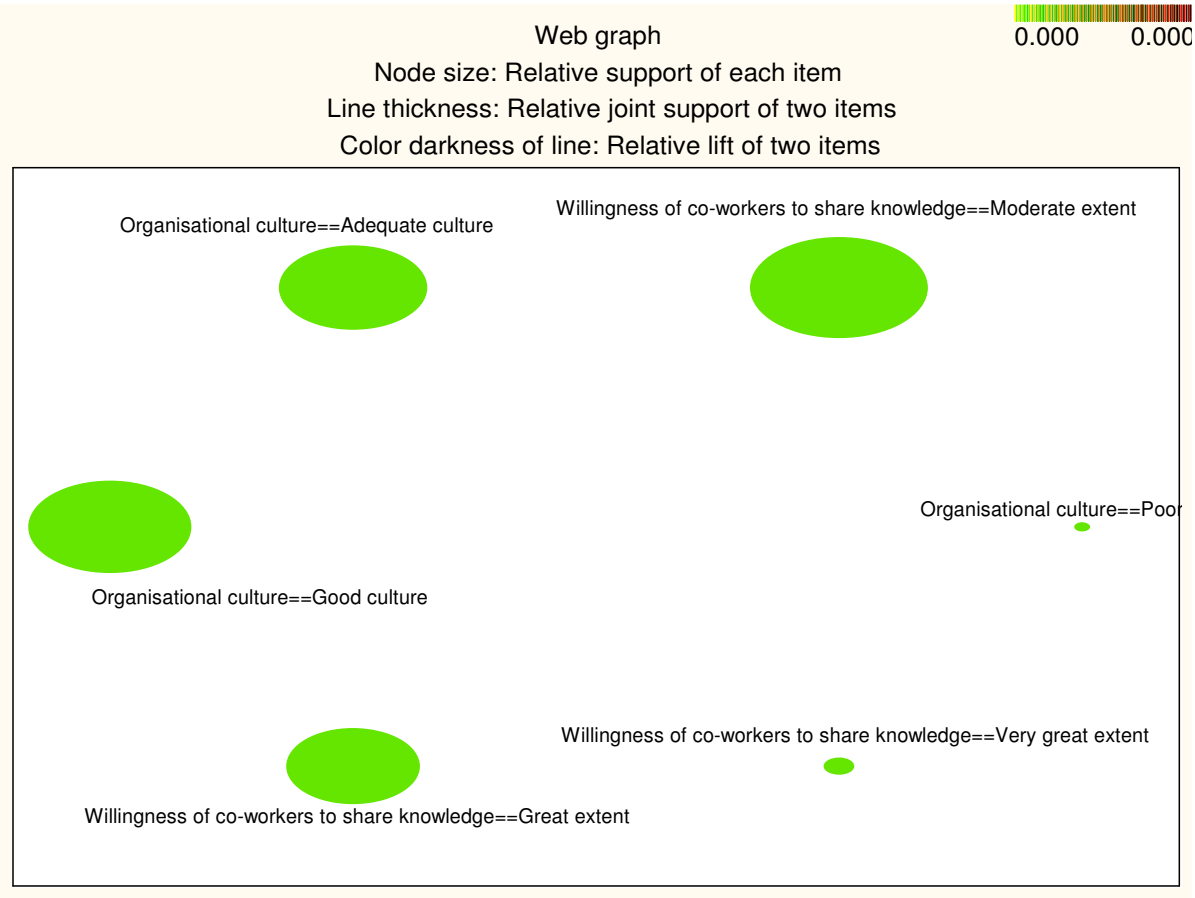


Figure 102: SAL for willingness of co-workers to share and organisational culture. Min support 0.1, confidence 0.1.

Nonetheless there is an overall trend, as the box plot of *Figure 103* shows. People perceive that their co-workers are more willing to share knowledge in better organisational culture. Perhaps this is a natural and defining characteristic of organisational culture in the first place?

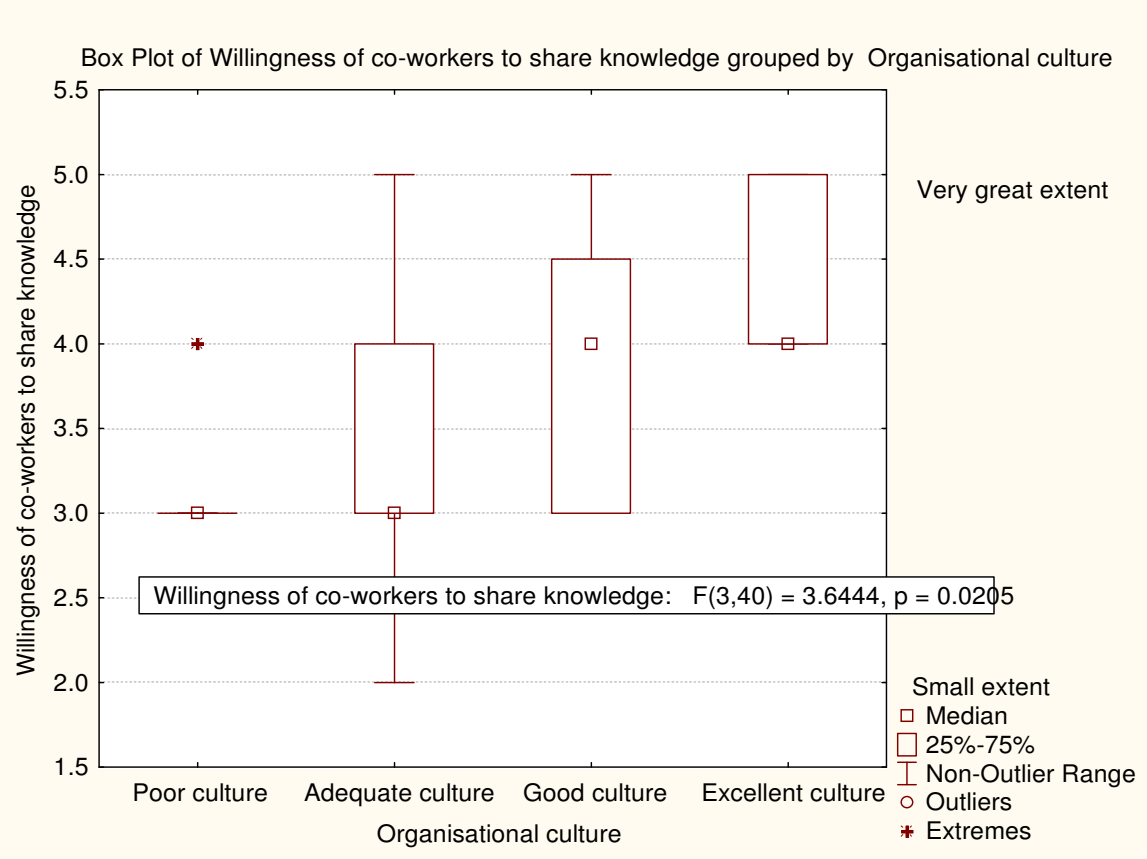


Figure 103: Box plot for willingness of co/workers to share knowledge and organisational culture.

4.7 What could be reasons for you to seek knowledge from others?

Figure 104 shows that there are various reasons for people to seek knowledge from others. There seems to be no particularly dominant reason to do so. However, the strongest factors were a person's willingness to improve their own knowledge, the pressure to succeed, personal interest and a good relationship with co-workers.

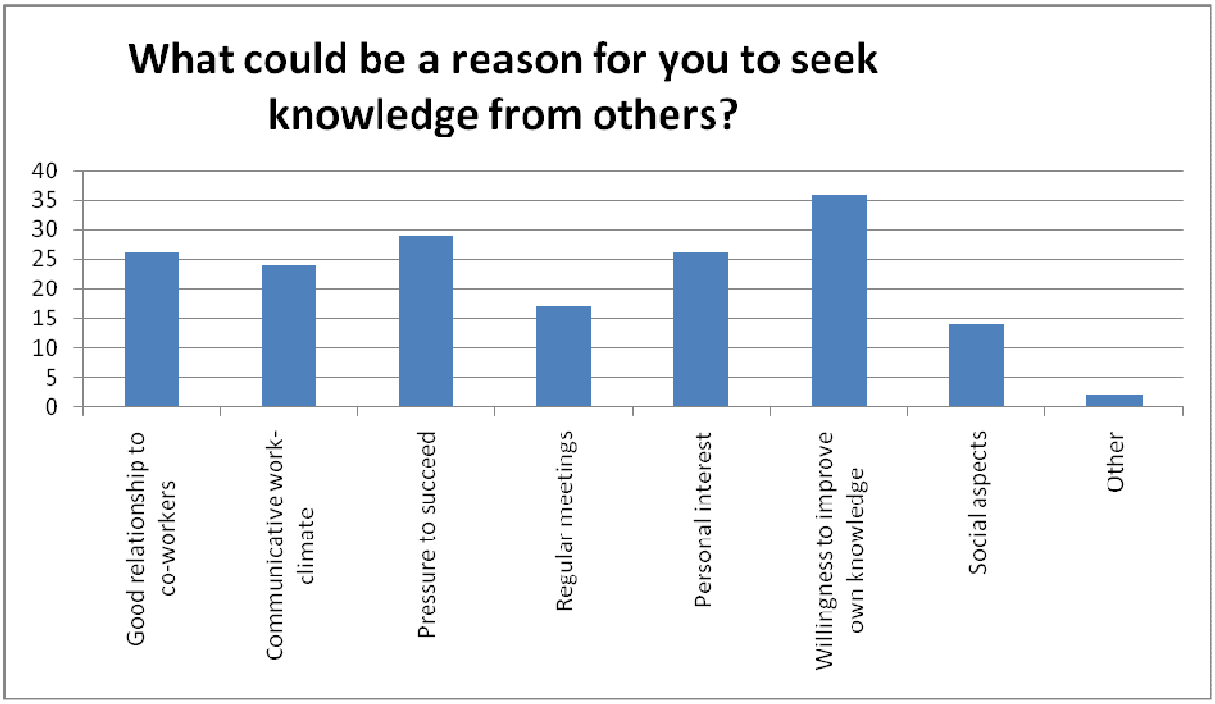


Figure 104

4.7.1 Comparison between New Zealand and Germany

No difference between the particular motivations to seek knowledge from co-workers could be found between New Zealanders and Germans, see *Figure 105-111*.

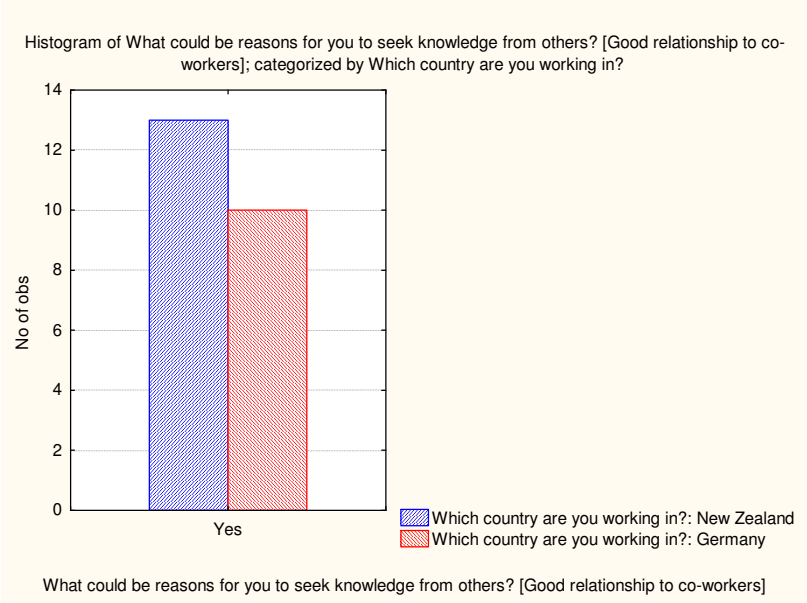


Figure 105

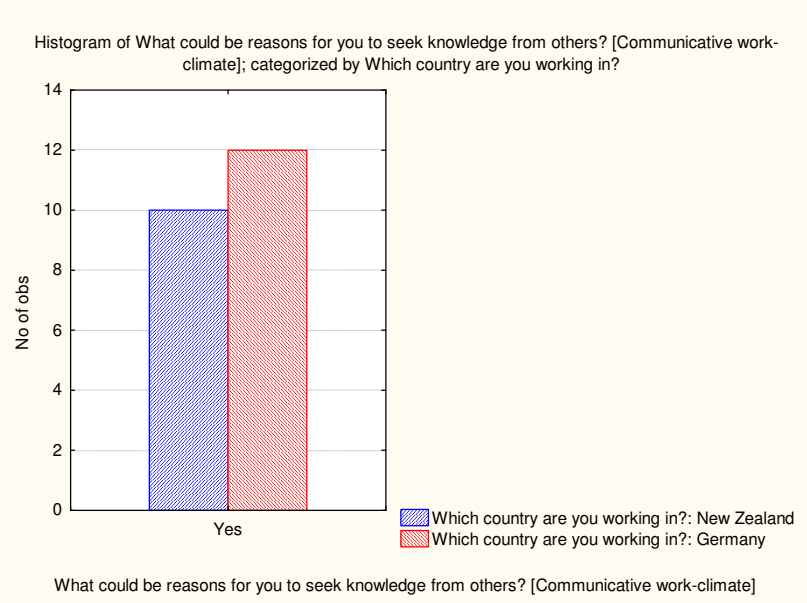


Figure 106

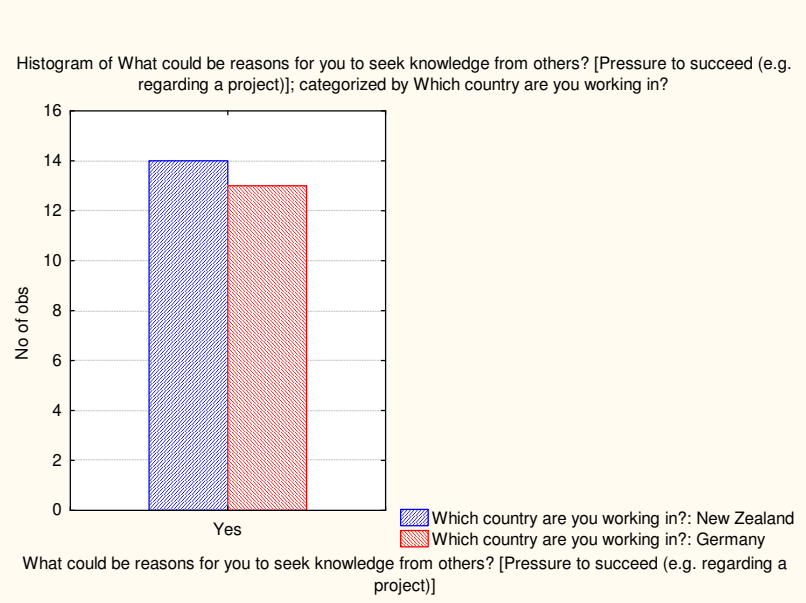


Figure 107

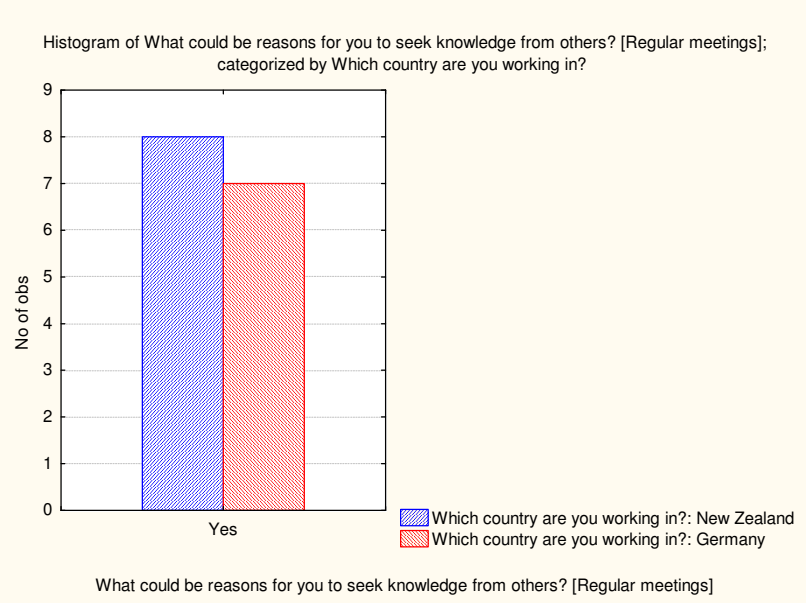


Figure 108

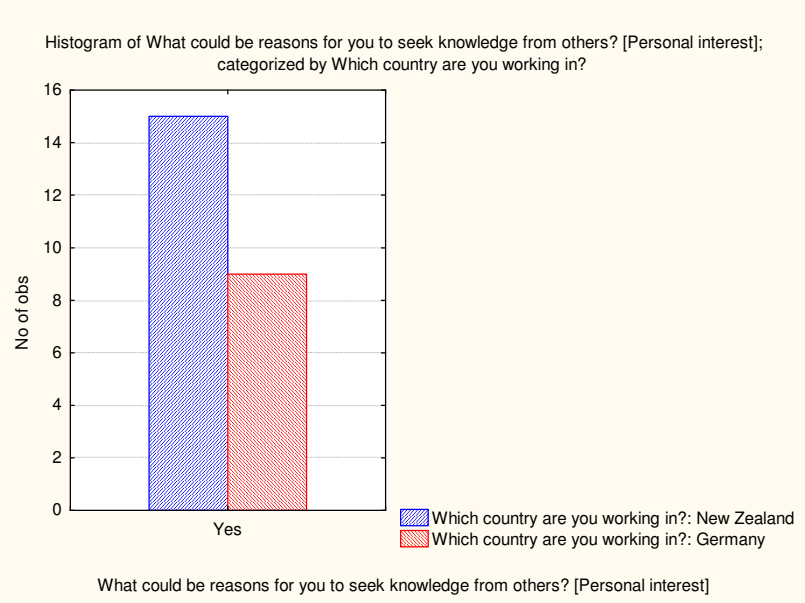


Figure 109

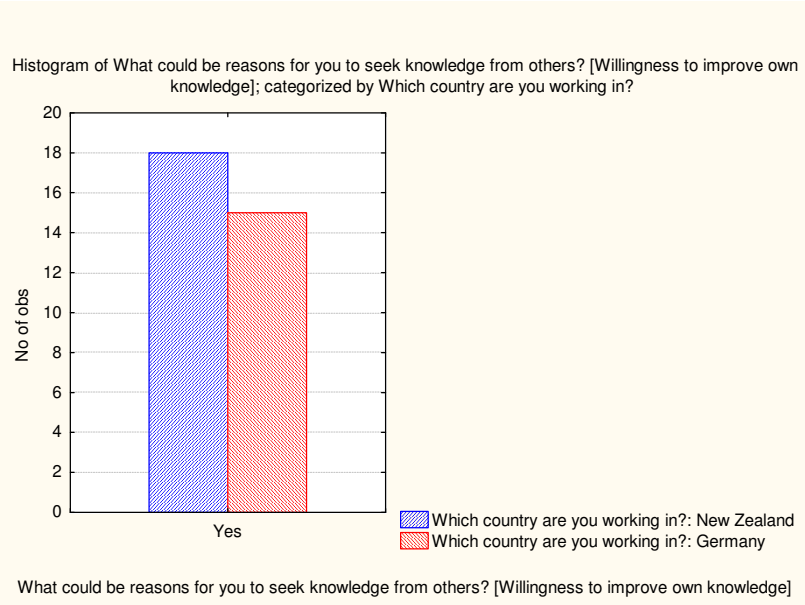


Figure 110

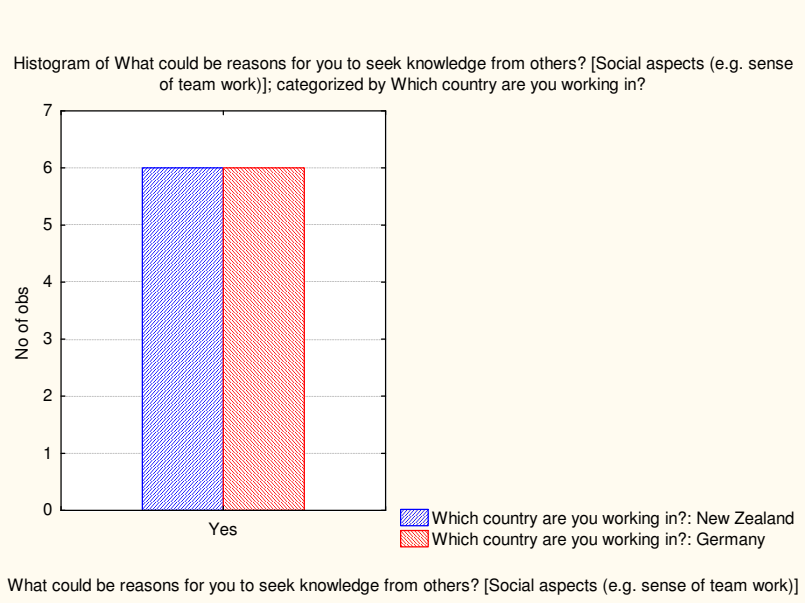


Figure 111

4.8 What would keep you from seeking knowledge from others?

As shown in *Figure 112,* the biggest reason not to seek knowledge from others is a poor relationship with them. Other important factors were that people found that they had no motivation or reason to do so and that they found they did not need their knowledge.

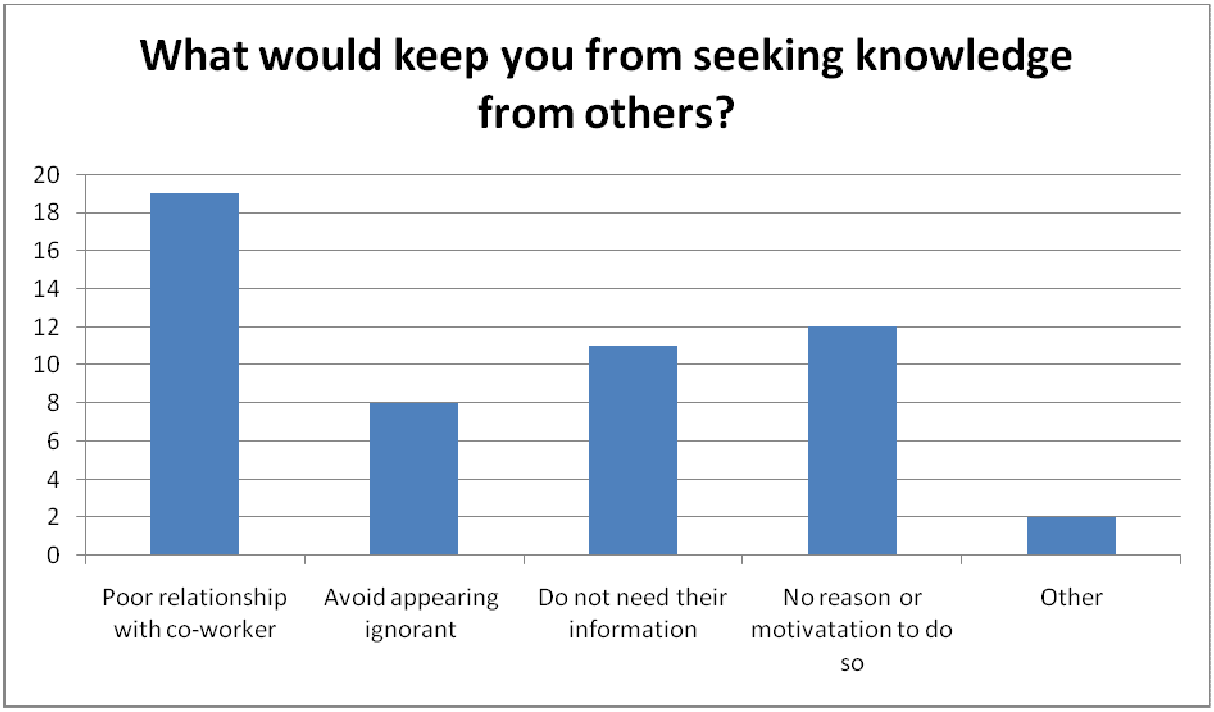


Figure 112

4.8.1 Comparison between New Zealand and Germany

New Zealanders seem to have a stronger tendency than Germans to think that there was no reason to seek knowledge from colleagues, see *Figure 116*. But no statistically significance was found, see *Figure 117*.

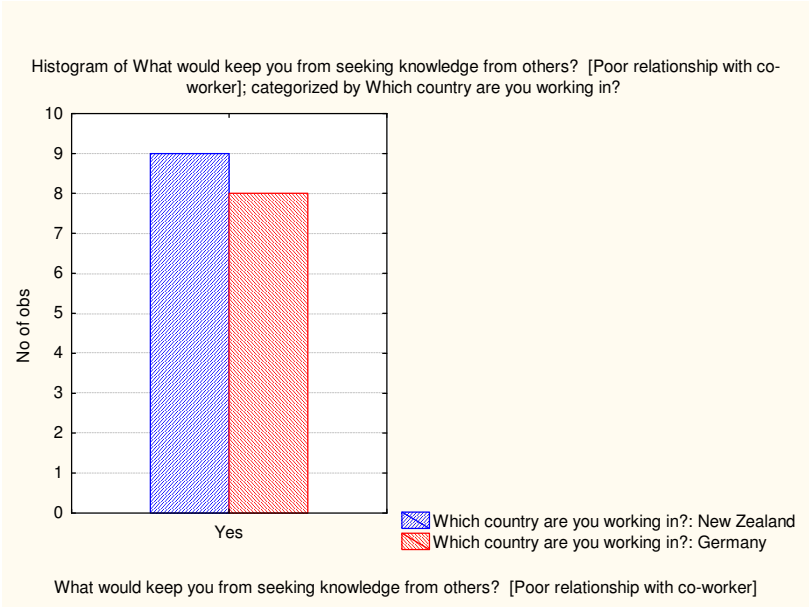


Figure 113

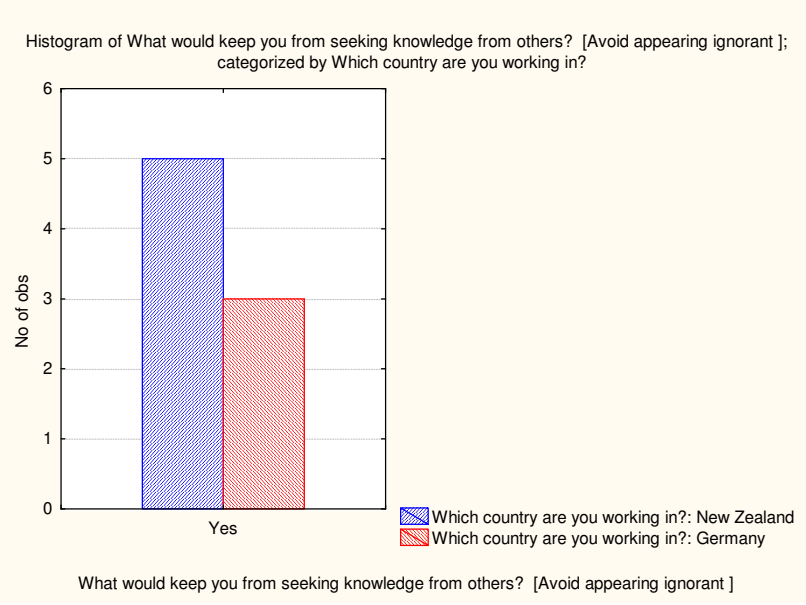


Figure 114

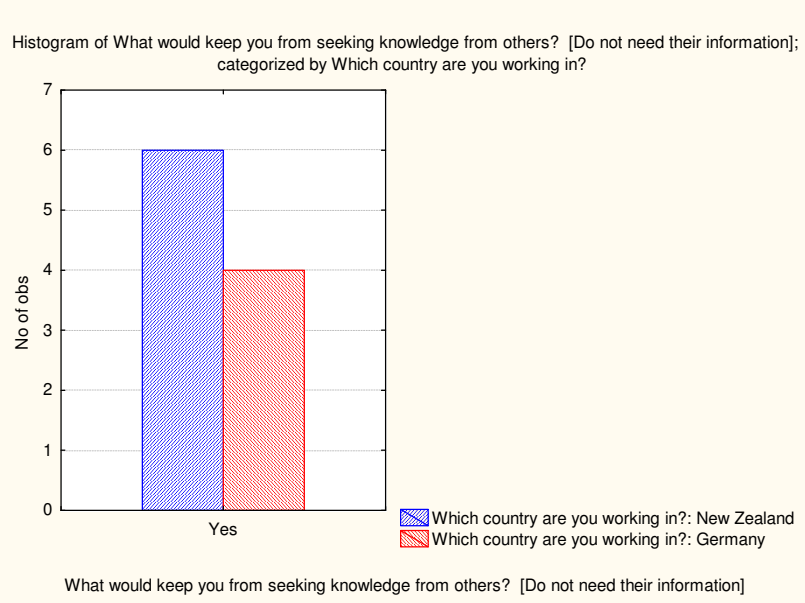


Figure 115

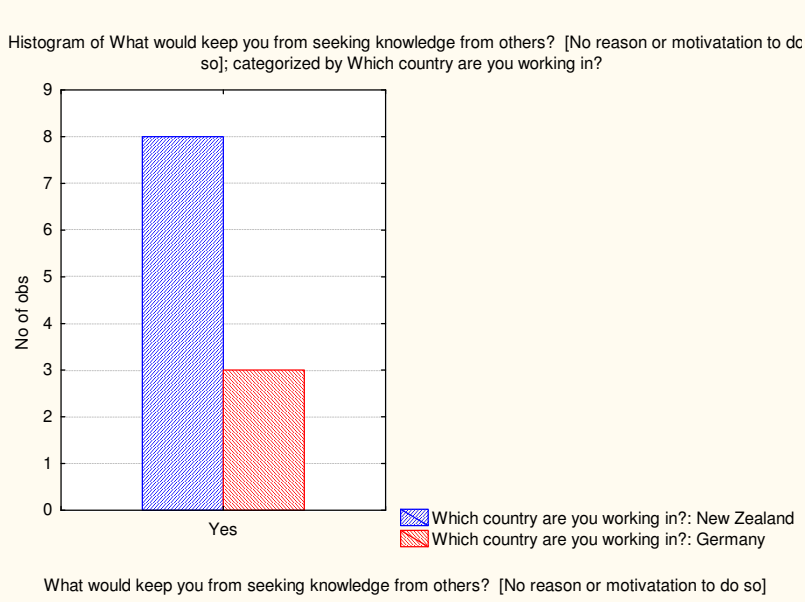


Figure 116

The differences shown in *Figure 116* are not statistically significant (ANOVA p=0.23), see *Figure 117*.

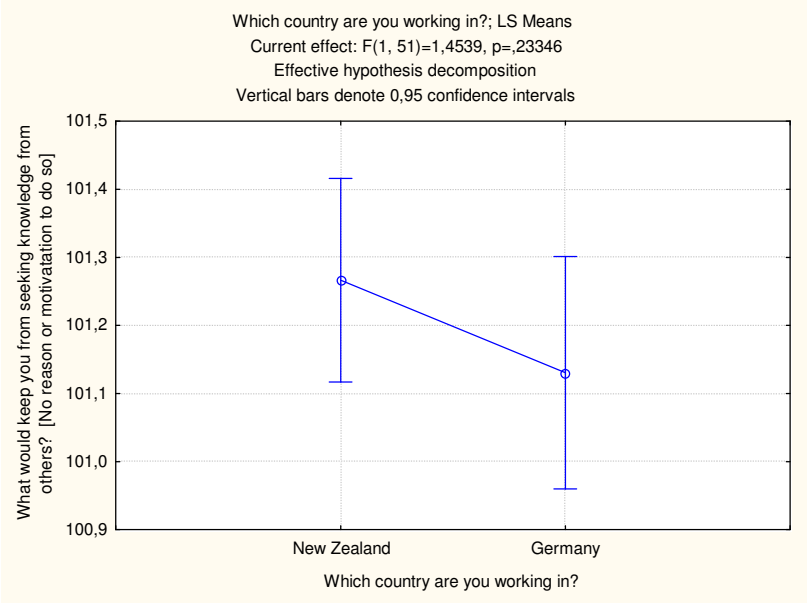


Figure 117

4.9 To what extent would you consider yourself an extraverted person?

Figure 118 shows that most people considered themselves moderately extraverted. The tendency is rather negative and more people thought they were not extraverted.

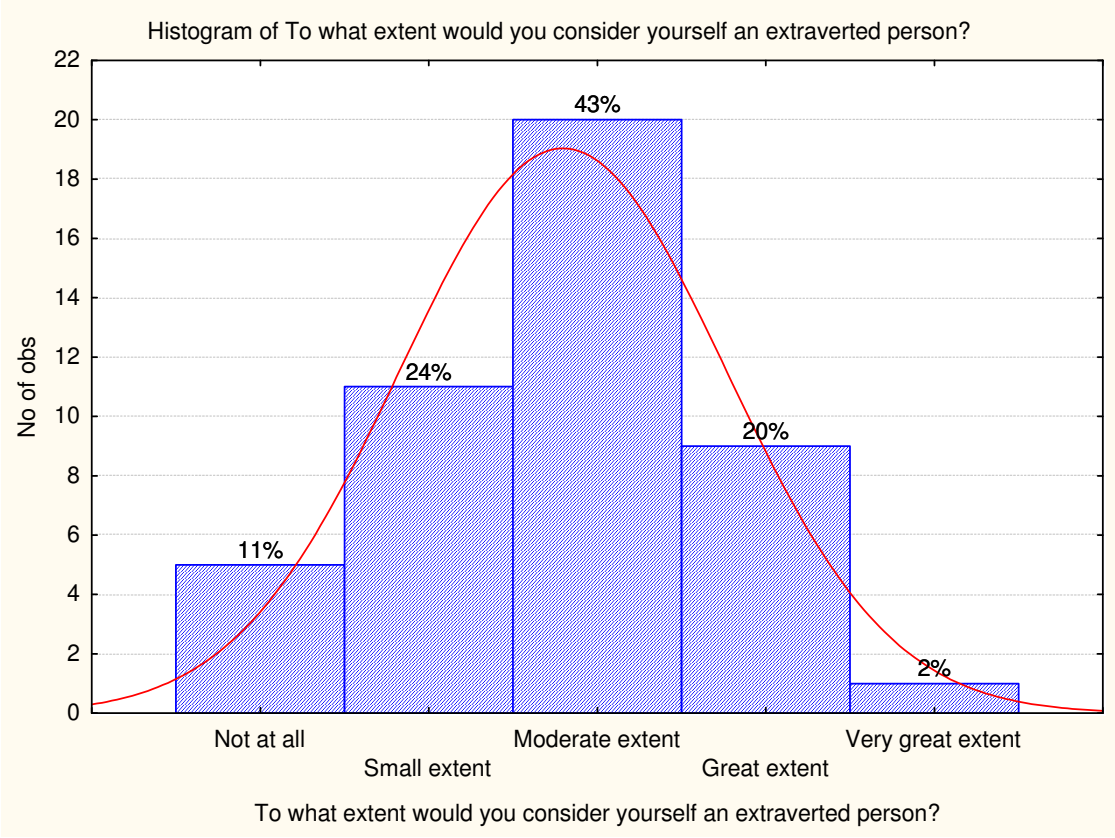


Figure 118

4.9.1 Comparison between New Zealand and Germany

Germans rate themselves more extraverted than New Zealanders (18% compared to 3% for great extent of extraversion), see *Figure 119*. This difference was proven statistically significant through ANOVA (p=0.01), see *Figure 120*.

This result is interesting, as New Zealanders rate their willingness to ask questions more positive than Germans. One could have expected people who rate themselves more extraverted to have a higher willingness to ask questions.

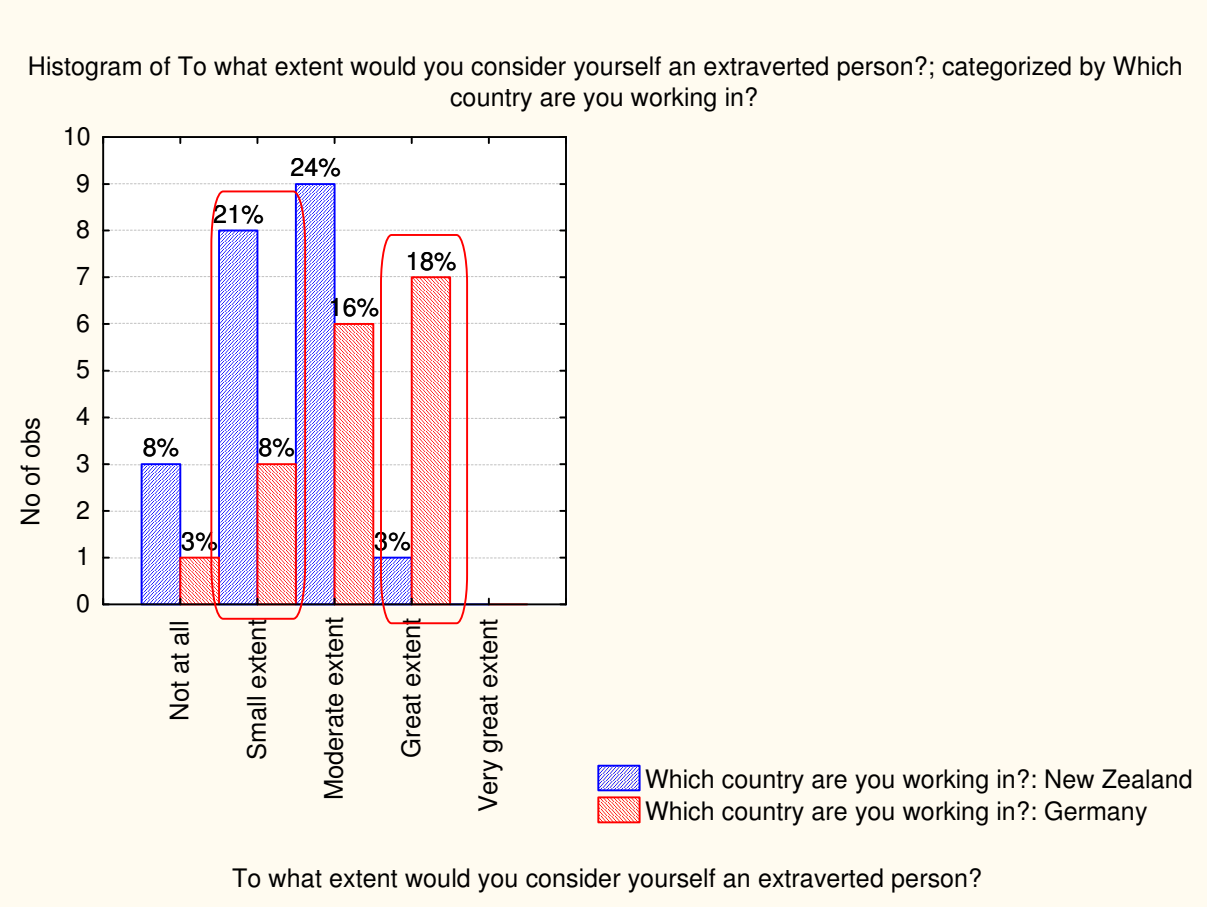


Figure 119

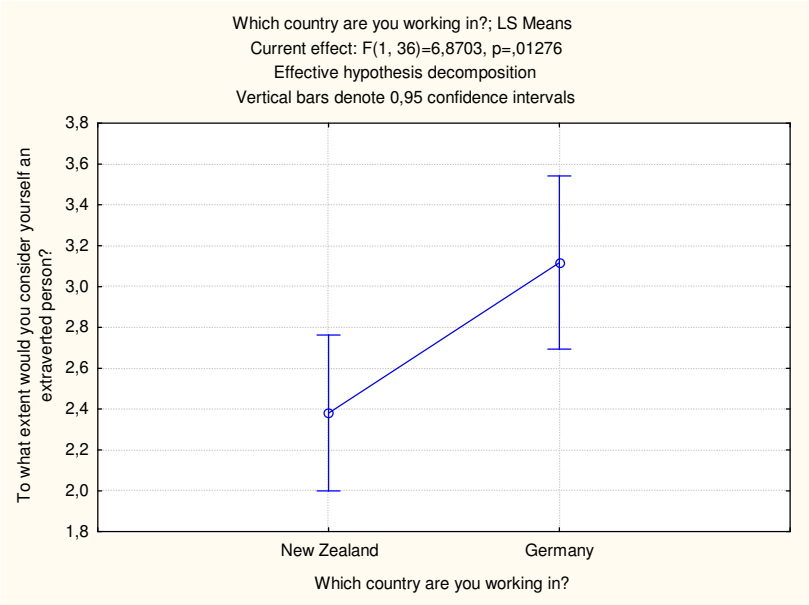


Figure 120

4.10 To what extent would you consider yourself an 'open' person?

As shown in *Figure 121*, more than half the survey respondents found themselves open to a great or very great extent. On the whole most people thought they were at least moderately open.

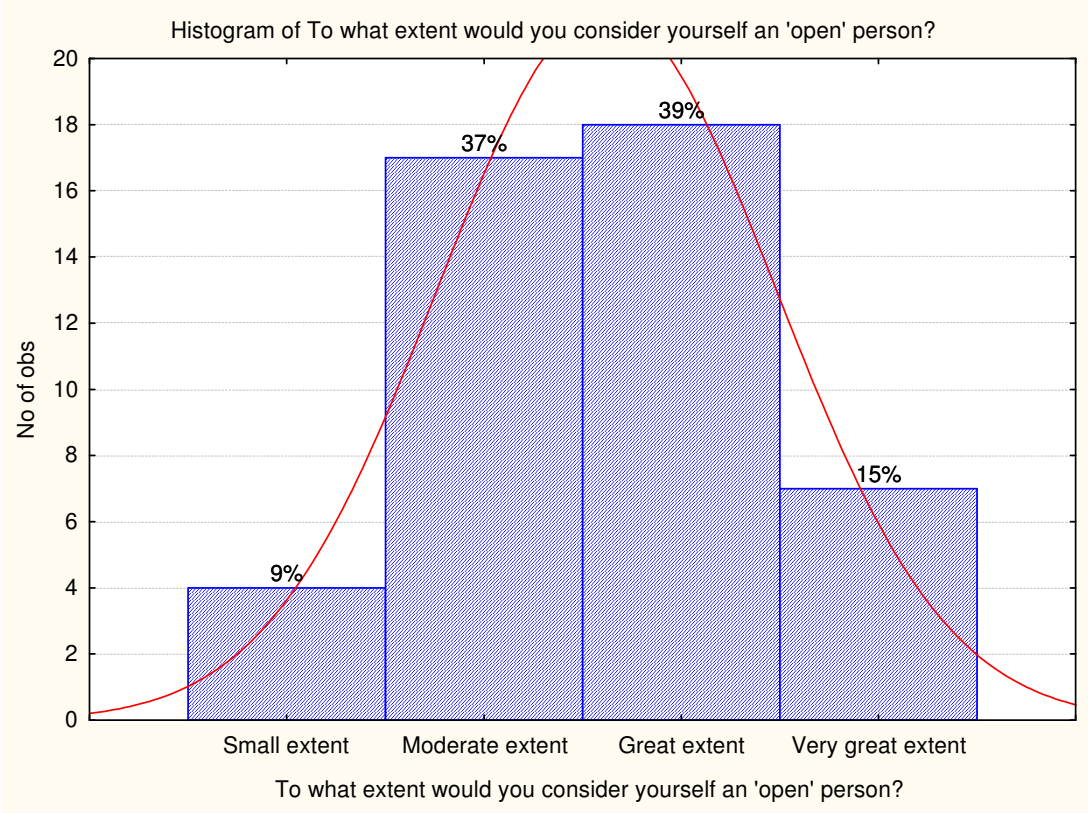


Figure 121

4.10.1 Comparison between New Zealand and Germany

Germans responded slightly more positive regarding their openness than New Zealanders, see *Figure 122*. Based on the ANOVA results, this is statistically insignificant (p=0.09), see *Figure 123*.

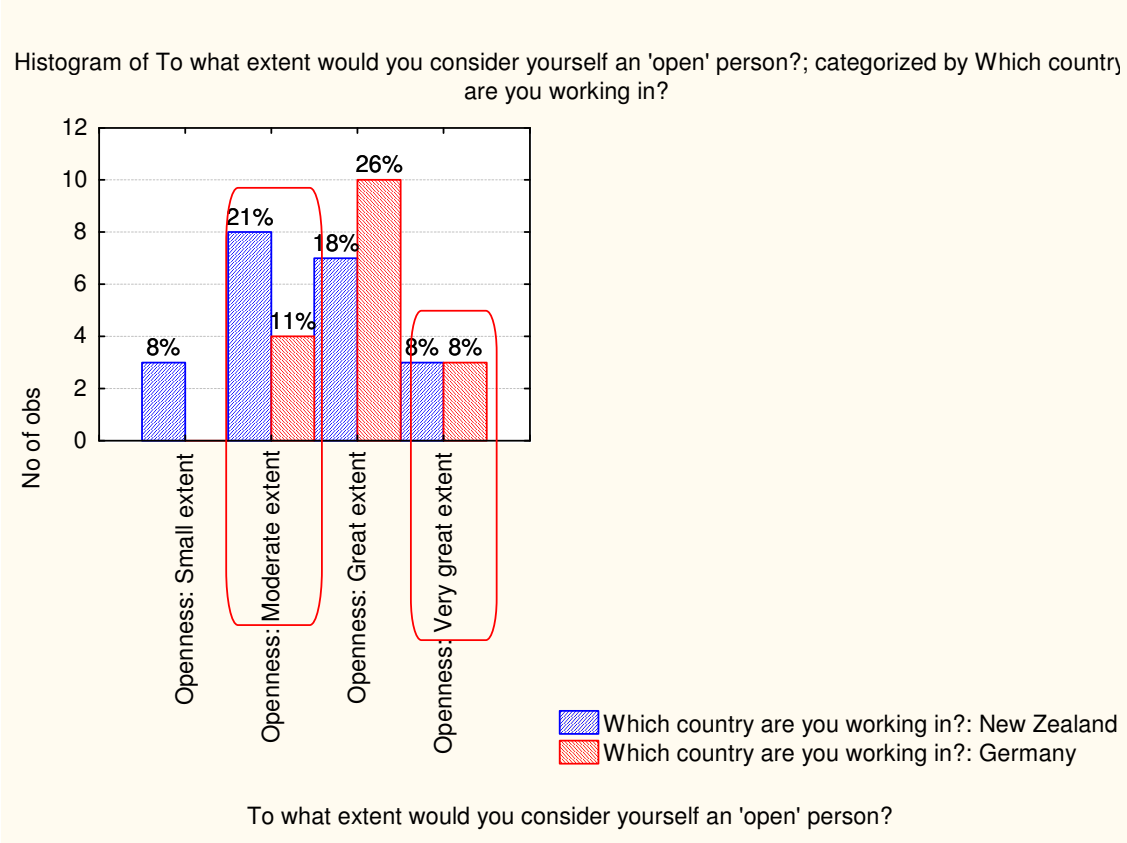


Figure 122

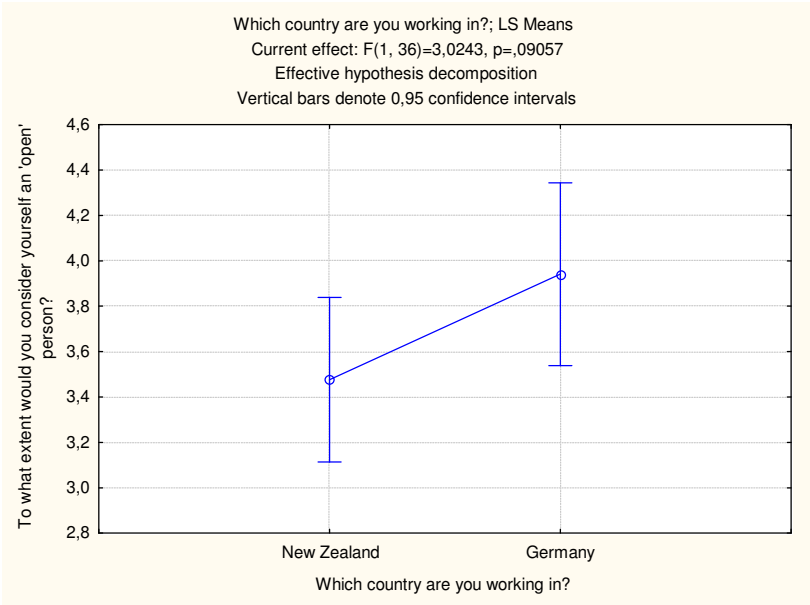


Figure 123

4.11 To what extent do HR management incentives suppress knowledge sharing?

The results show that the influence of HR incentives is rather low. 58% of the survey respondents rate the impact of HR incentives as insignificant ('not at all' to 'small extent'), 33% they have a moderate influence, see *Figure 124*.

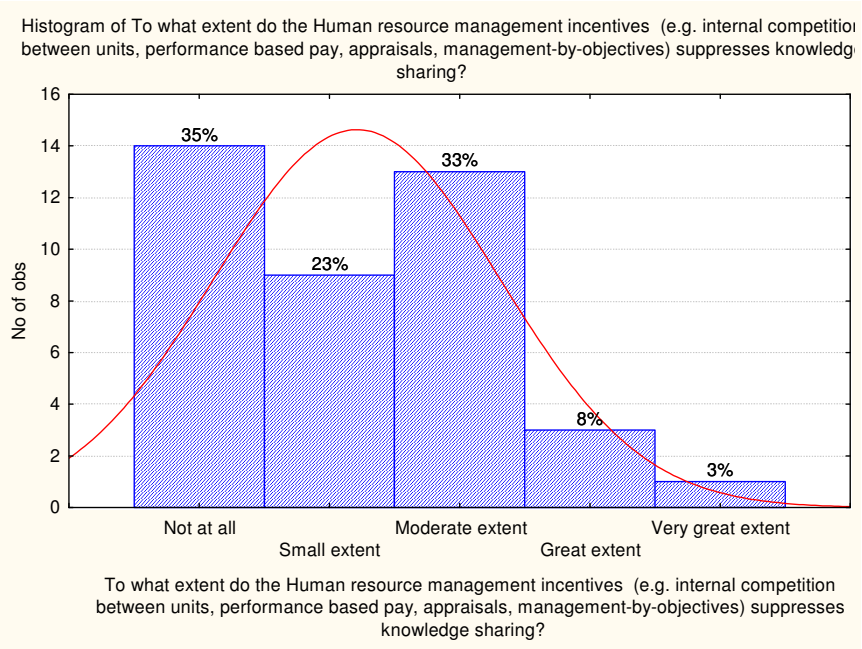


Figure 124

4.11.1 Comparison between New Zealand and Germany

There are no significant differences between New Zealand and Germany.

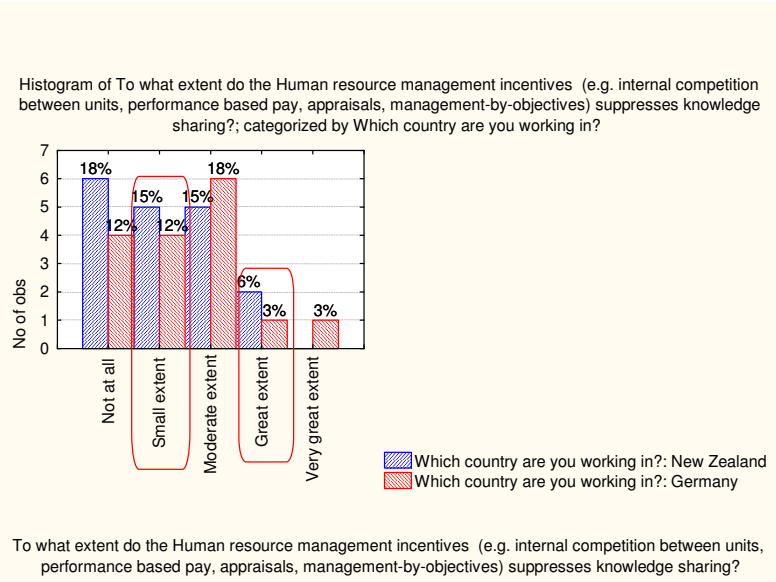


Figure 125

4.12 Where there is a willingness to share knowledge, is it stronger within a workgroup than in the wider organisation?

Figure 126 shows that on the whole it seems like the willingness to share knowledge is greater in workgroups than in the wider organisation (74% said 'cautiously yes' to 'definitely yes').

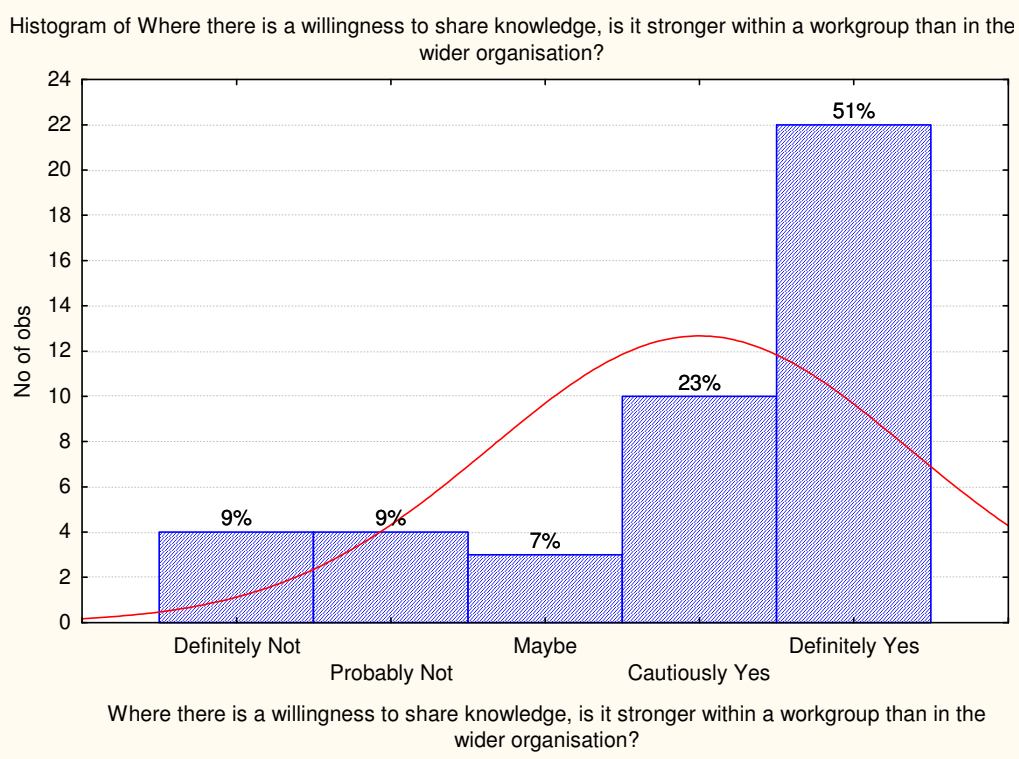


Figure 126

4.12.1 Comparison between New Zealand and Germany

There are no significant differences between New Zealand and Germany.

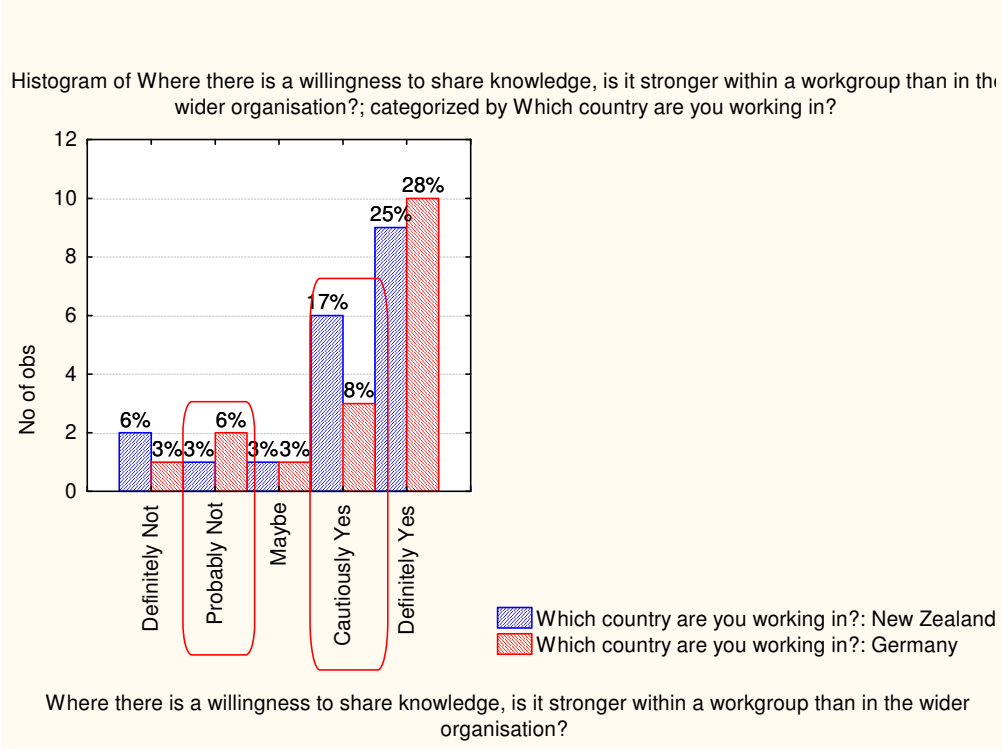


Figure 127

5 Organizational Relationships

5.1 To what extent does the kind of relationship you have to your co-workers influence your willingness to share knowledge or ask them to do so?

The influence of personal relationships of co-workers has a rather significant impact on the knowledge transfer process between them, see *Figure 128*. 50% of the respondents found that the influence was great or very great, while 33% found it was moderate. Only 18% found that it had a small impact or none at all.

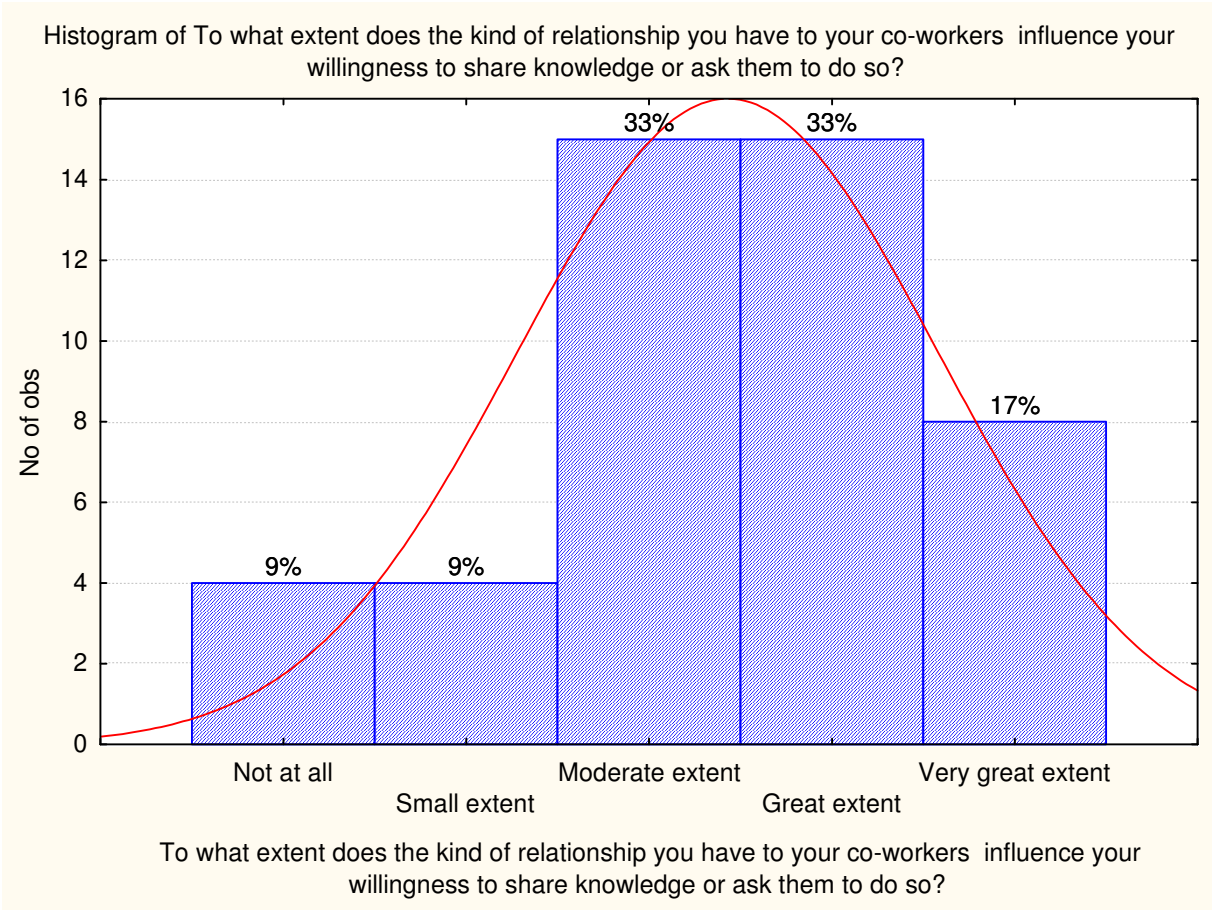


Figure 128

5.1.1 Comparison between New Zealand and Germany

The results show that the influence of personal relationships is even greater in German companies than in New Zealand. No German survey respondent found that the personal relationship to their co-workers had only a low influence, or none, see *Figure 128*. The difference is statistically significant, see *Figure 129* (p=0.02).

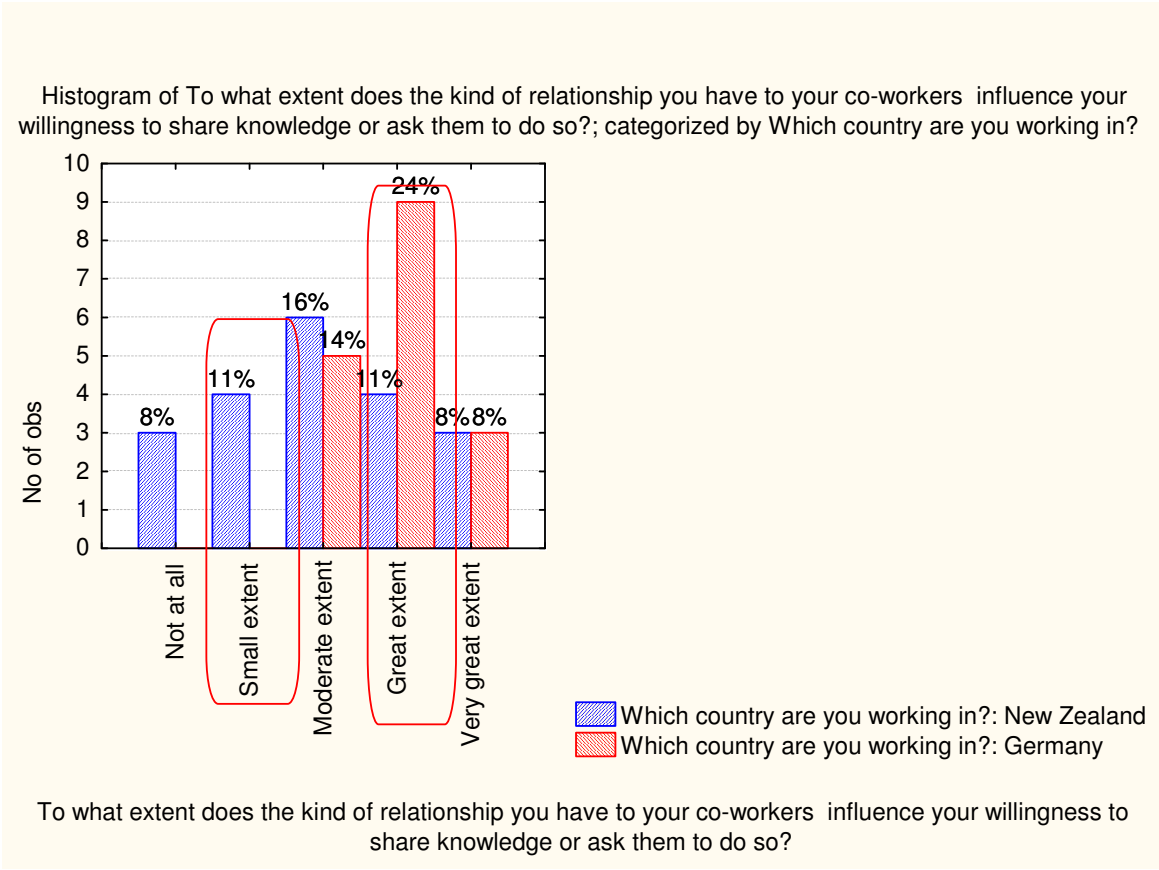


Figure 129

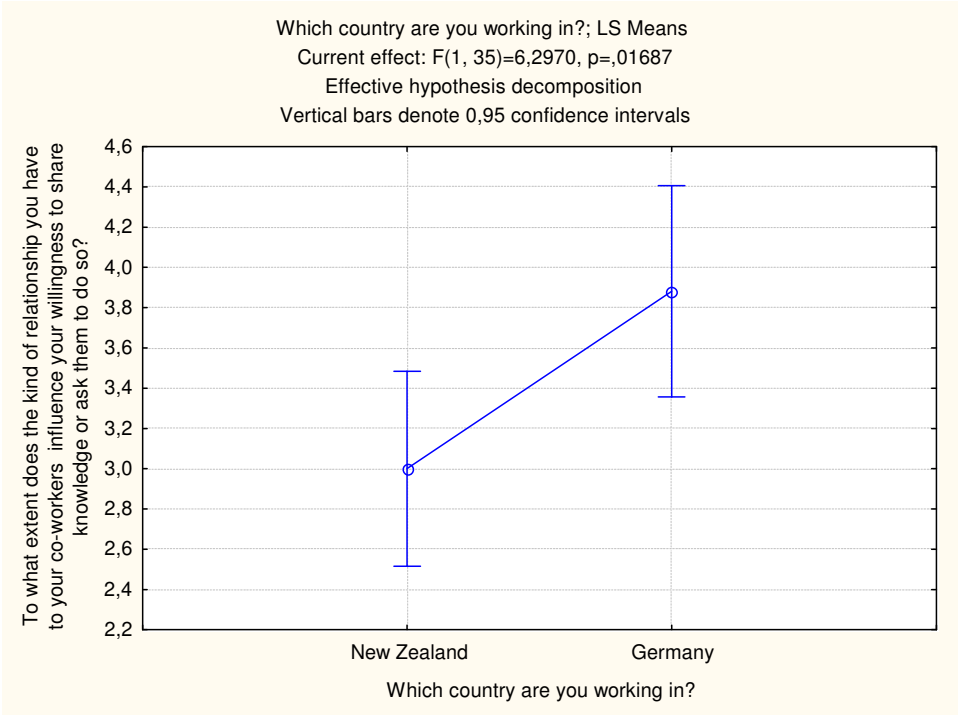


Figure 130

5.2 To what extent does trust influence your willingness to share and ask for knowledge?

On the whole trust has a great influence on knowledge sharing processes in a company, see *Figure 131*. For 65% of the survey participants thought that trust has a great or very great influence on sharing and asking for knowledge.

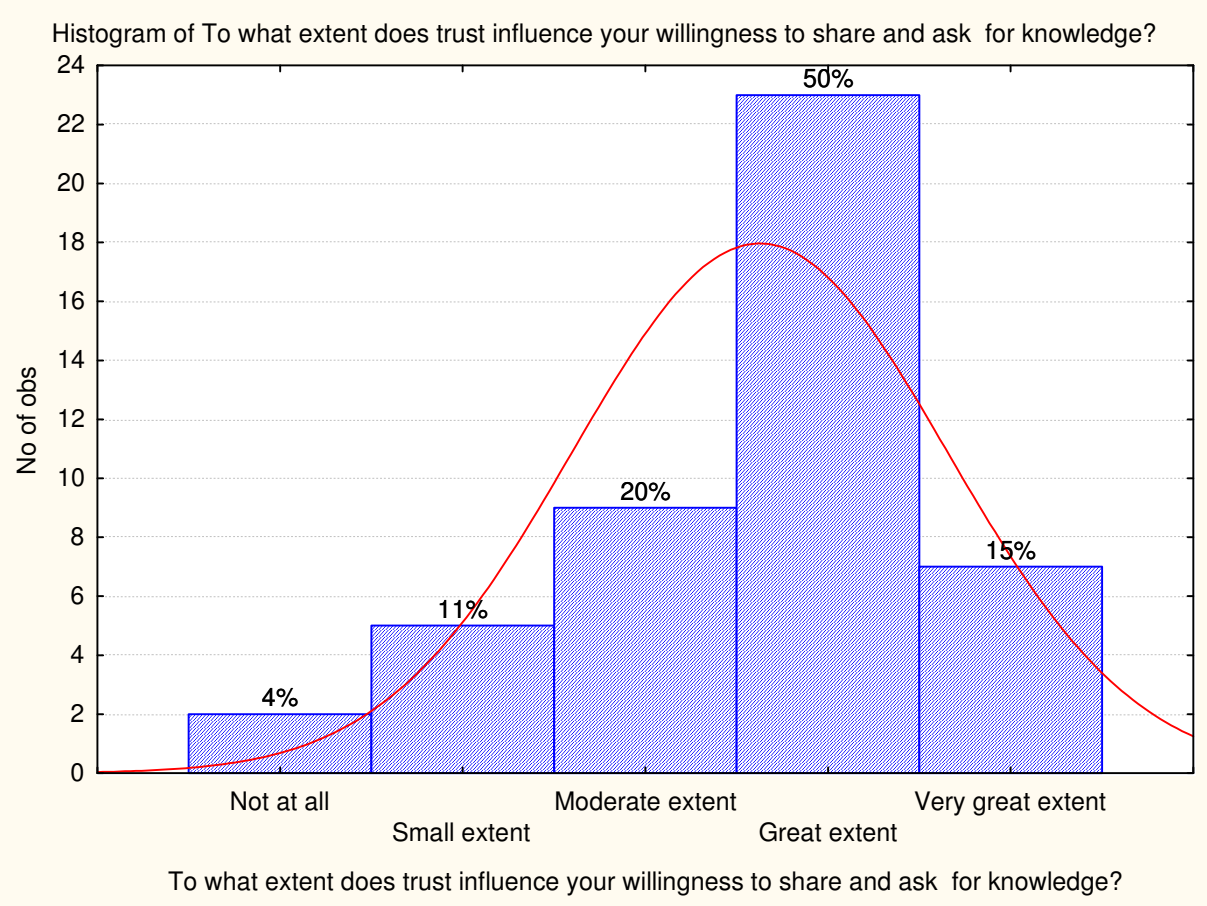


Figure 131

5.2.1 Comparison between New Zealand and Germany

People in Germany found that the influence of trust for knowledge sharing is higher than the New Zealanders, see *Figure 132*. ANOVA showed that this result is statistically significant (p=0..00), see *Figure 133*.

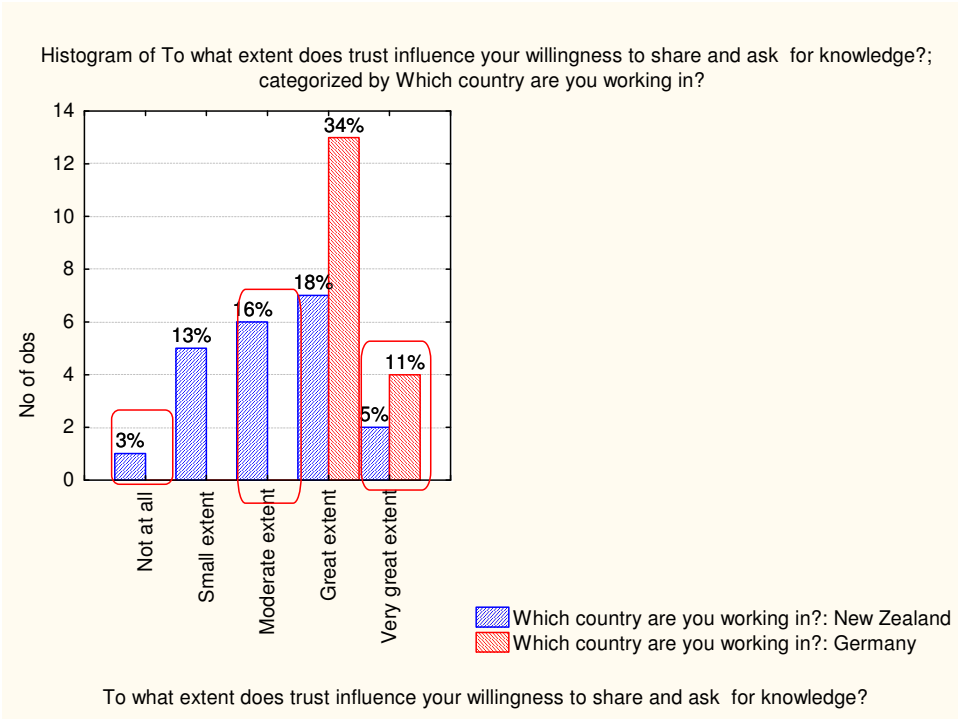


Figure 132

Figure 133

5.3 How would you rate the general climate (organisational culture) in your company?

Most survey participants (72%) rated the climate in their company adequate or good, see *Figure 134.*

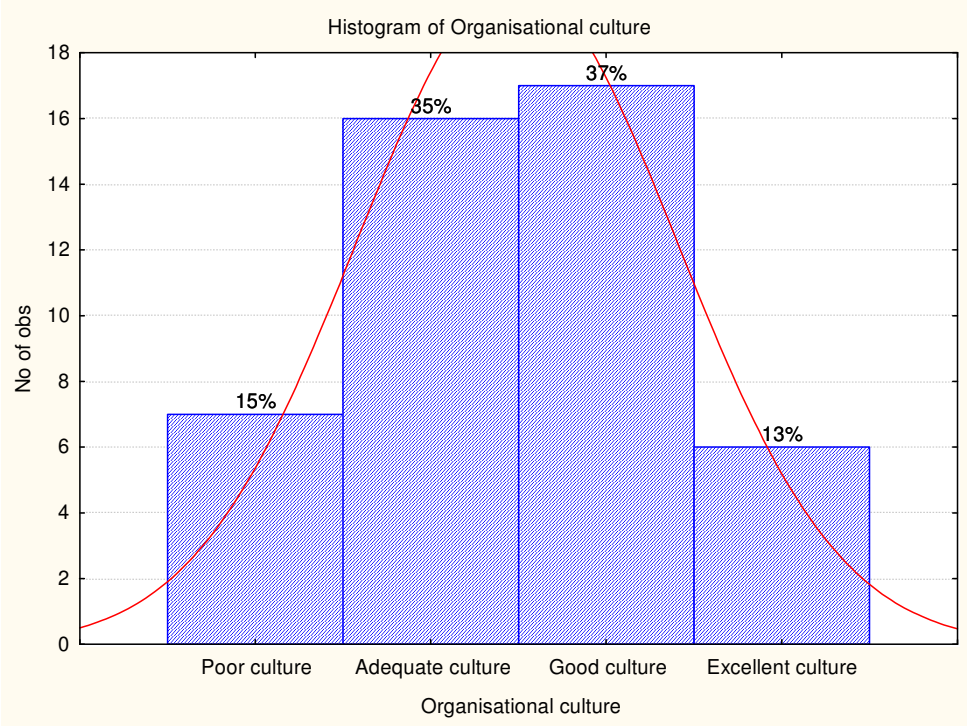


Figure 134

5.3.1 Comparison between New Zealand and Germany

No significant difference between New Zealand and Germany could be found.

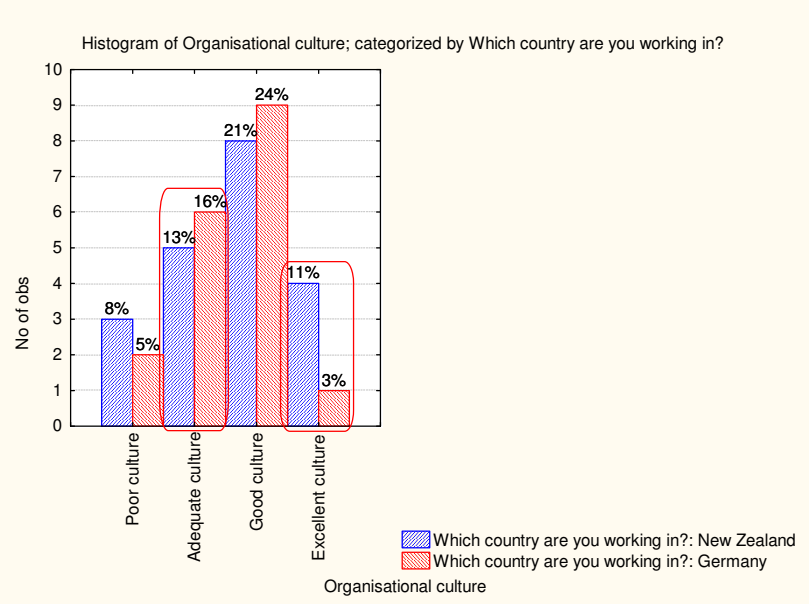


Figure 135

5.4 How important is the following for you regarding your job?

Figure 136 shows that the most important things for survey participants regarding jobs were challenging tasks, the work-climate and job security. The salary and the work-life-balance were close to the top three was well.

	Mean Importance
Challenging tasks	4,17
Work climate	3,94
Job security	3,89
Salary	3,87
Work-life balance	3,85
Working hours	3,43
Location of the company	3,43
Reputation of the company	3,34
Chance for promotion	3,04
Chance to work overseas	2,43

Figure 136

5.5 Which of the following roles are you most comfortable performing in a project team?

As displayed in *Figure 137,* half the respondents felt most comfortable as the leader in a project team, while 22% prefer to be a team-player and 22% prefer to contribute as specialists.

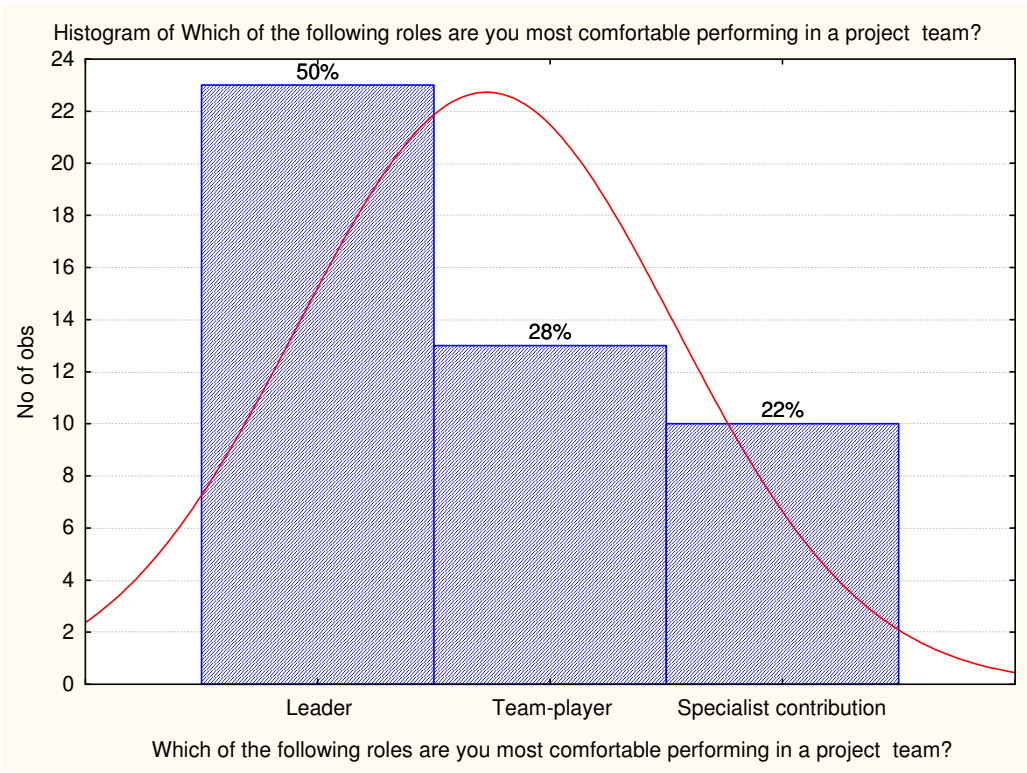


Figure 137

5.5.1 Association with willingness to share

The SAL showed an association between survey respondents that feel comfortable in leader roles and a great or even very great willingness to share their knowledge. Also an association between team-players and a great willingness to share could be found, see *Figure 138.*

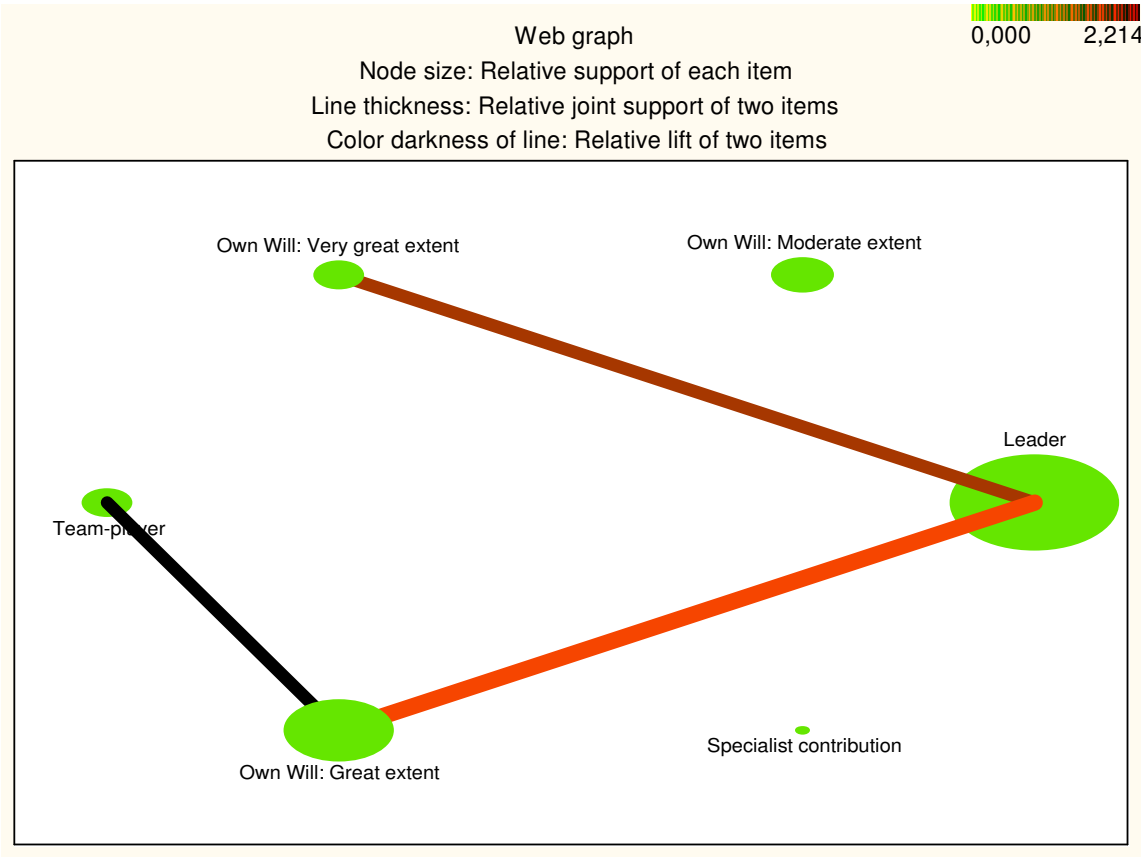


Figure 138: SAL for the preferred role in a team and the willingness to share knowledge. Min. support 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.10.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Own Will: Great extent	==>	Leader	12,16216	50,00000	1,608696
2	Leader	==>	Own Will: Great extent	12,16216	39,13043	1,608696
3	Own Will: Very great extent	==>	Leader	9,45946	53,84615	1,732441
4	Leader	==>	Own Will: Very great extent	9,45946	30,43478	1,732441
5	Own Will: Great extent	==>	Team-player	9,45946	38,88889	2,213675
6	Team-player	==>	Own Will: Great extent	9,45946	53,84615	2,213675

Figure 139

5.5.2 Association with willingness to ask questions

SAL showed that leaders tend to have a great or very great willingness to ask questions. Also an association between team-players and a great willingness to ask questions can be seen, see *Figure 140*.

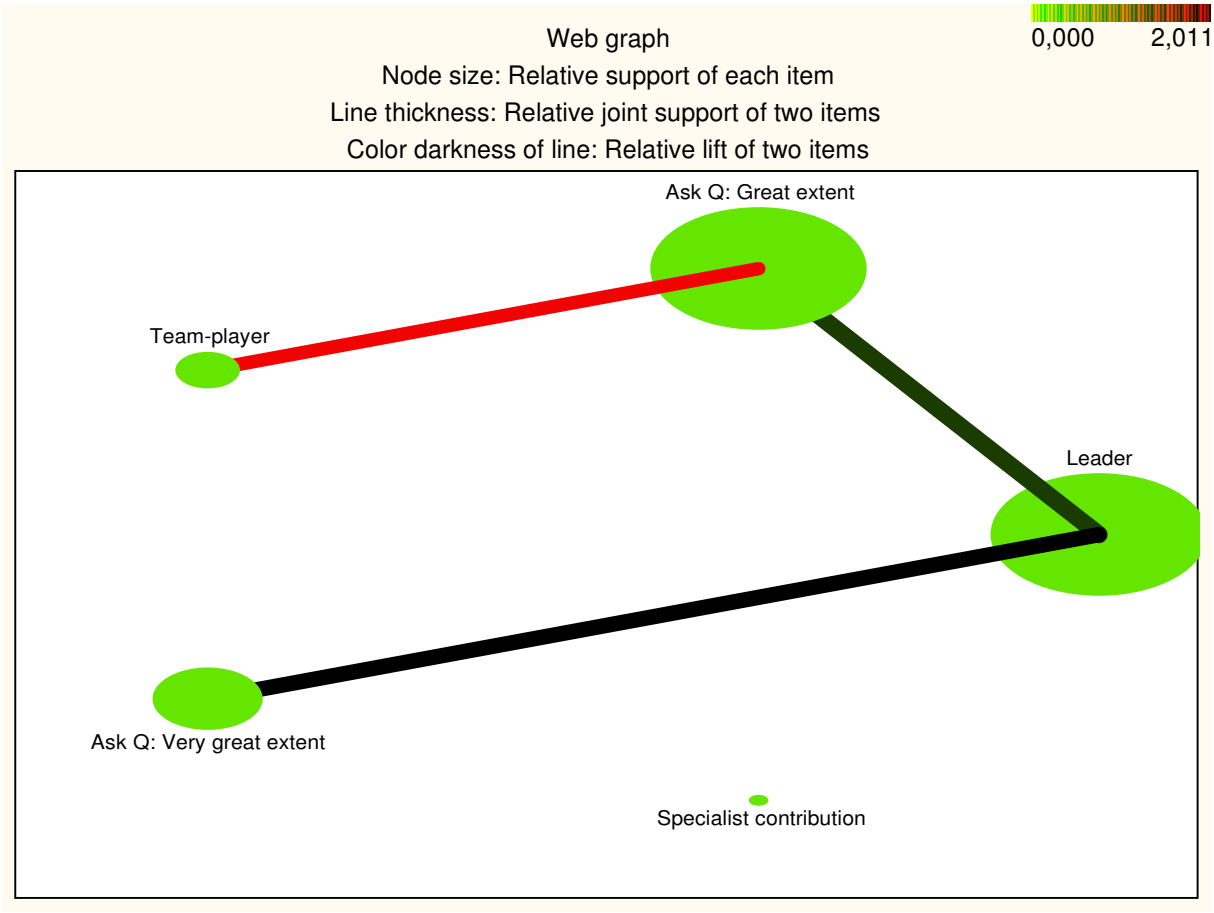


Figure 140: SAL for the preferred role in a team vs. the willingness to ask. Min. support 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.10.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Ask Q: Very great extent	==>	Leader	13,51351	62,50000	2,010870
2	Leader	==>	Ask Q: Very great extent	13,51351	43,47826	2,010870
3	Ask Q: Great extent	==>	Leader	14,86486	47,82609	1,538752
4	Leader	==>	Ask Q: Great extent	14,86486	47,82609	1,538752
5	Team-player	==>	Ask Q: Great extent	10,81081	61,53846	1,979933
6	Ask Q: Great extent	==>	Team-player	10,81081	34,78261	1,979933

Figure 141

5.6 In a project or within the organisation, to what extent do you contribute to setting direction?

Almost half the respondents (49%) contribute to setting direction within a project or their organisation (great to very great extent), while 28% found they contribute to a moderate extent, see *Figure 142*.

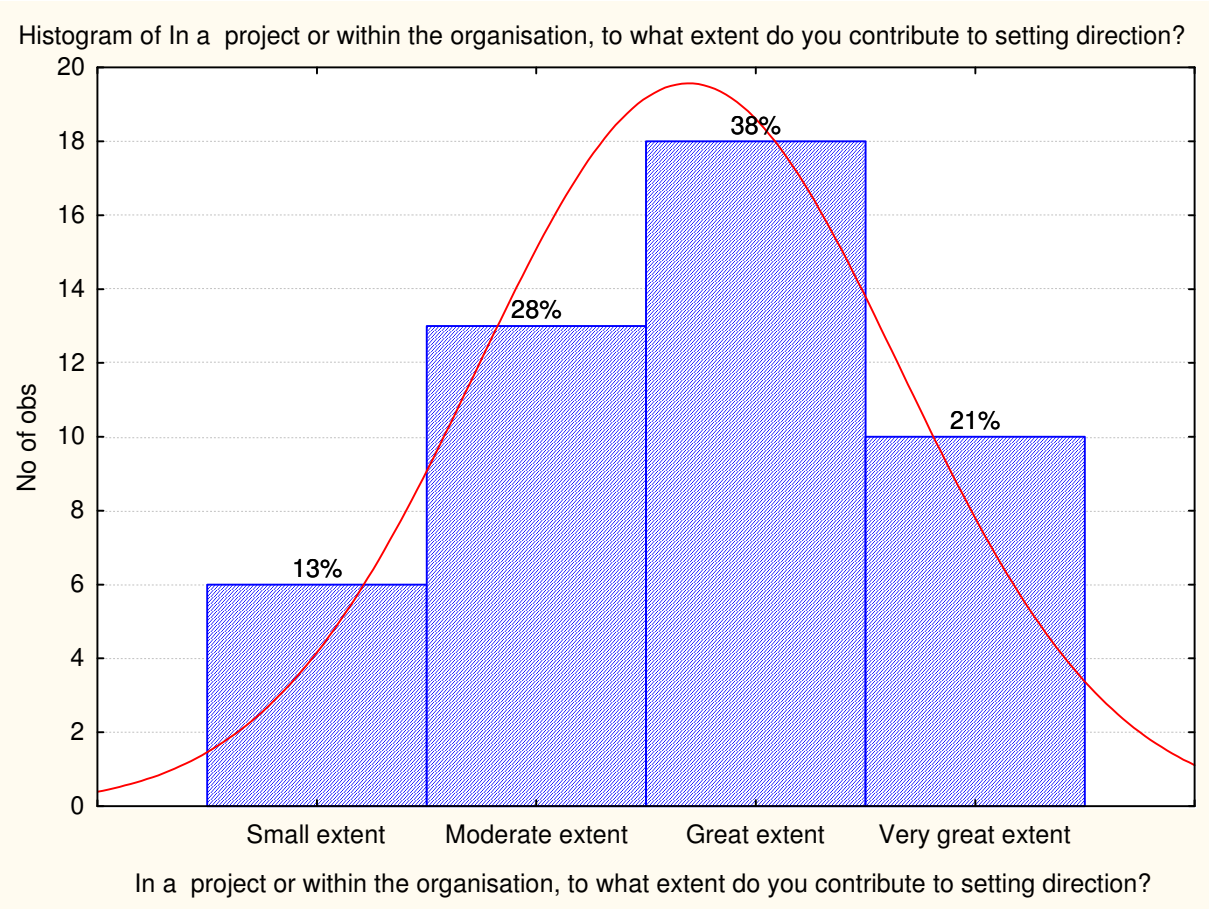


Figure 142

5.7 How easy do you find it to seek knowledge from superiors, peer and subordinates?

Seeking knowledge from peers was found the easiest, see *Figure 145*. While seeking knowledge from superiors was considered the hardest, see *Figure 143*.

Superiors

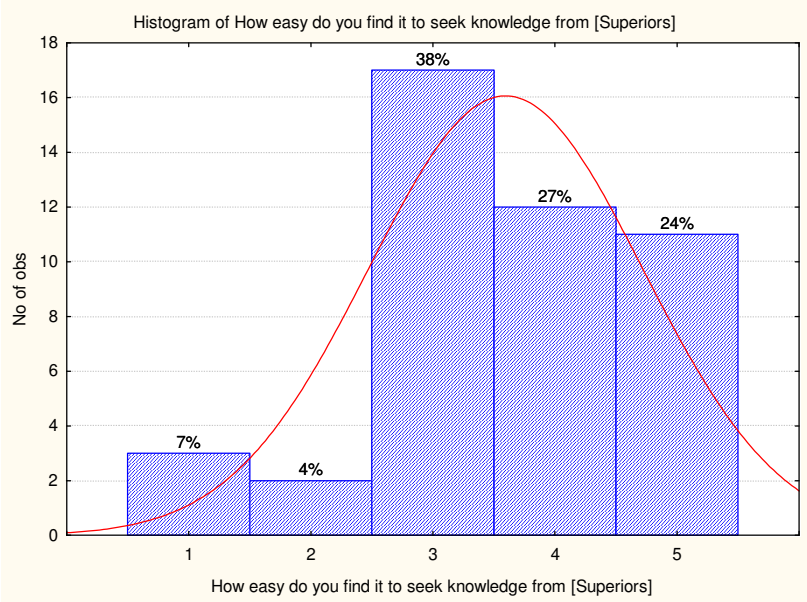


Figure 143

Subordinates

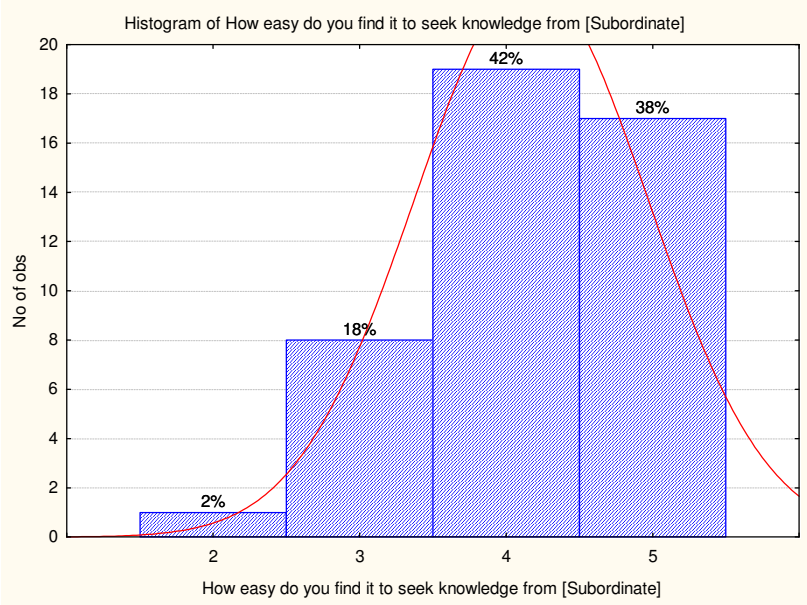


Figure 144

Peers

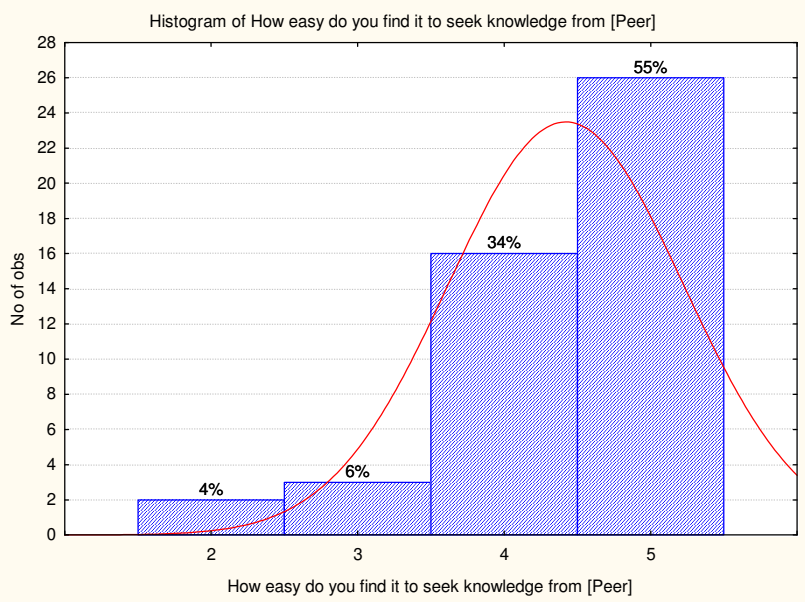


Figure 145

5.7.1 Comparison between superiors, peers and subordinates

As shown in Figure 146 and 147, people found it easier to seek knowledge from peers and subordinates than from superiors. While survey participants found it the easiest to seek for knowledge from peers, seeking knowledge from superiors was considered the hardest.

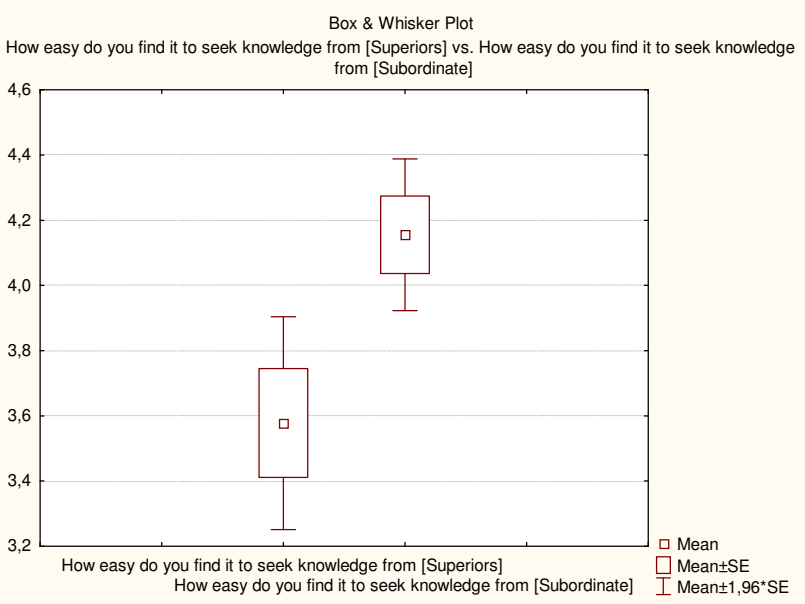


Figure 146

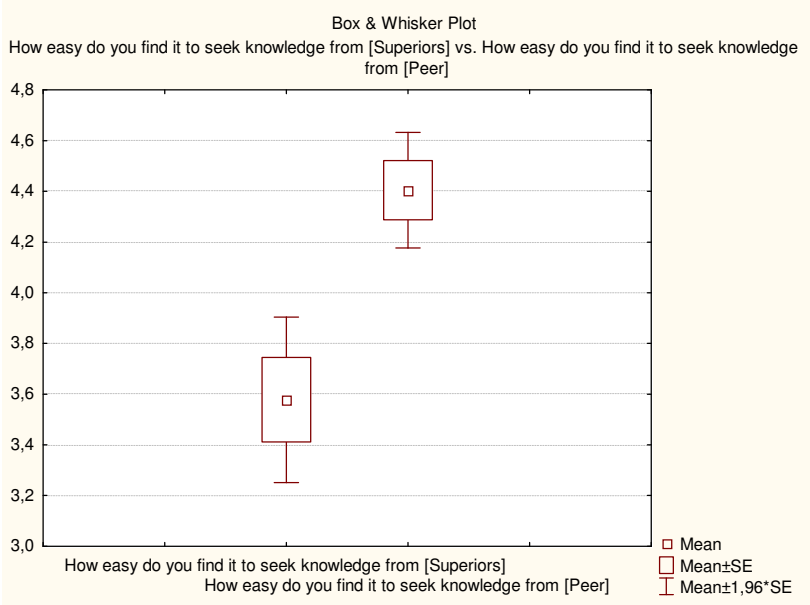


Figure 147

The survey respondents found that it was the easiest to seek knowledge from peers than from subordinates, see *Figure 147.*

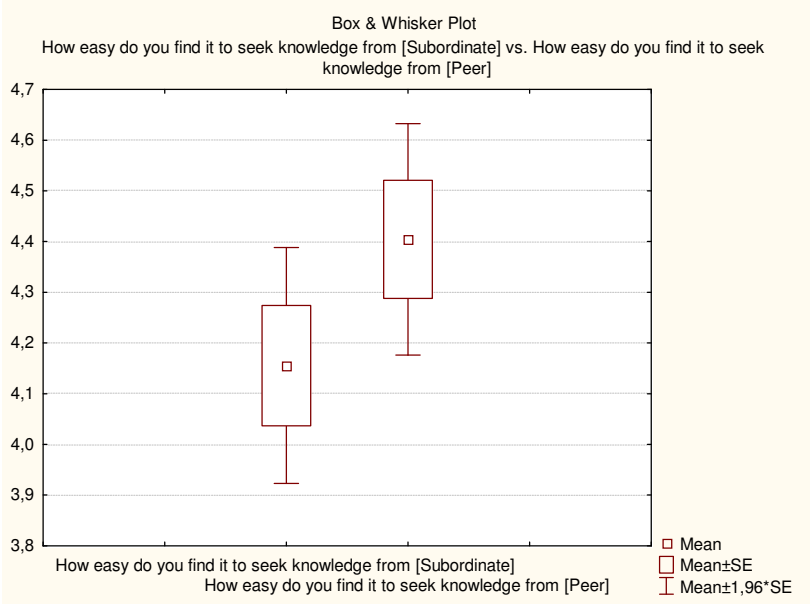


Figure 148

6 New Product Development

6.1 At what stage during NPD does your company tend to use KM methods?

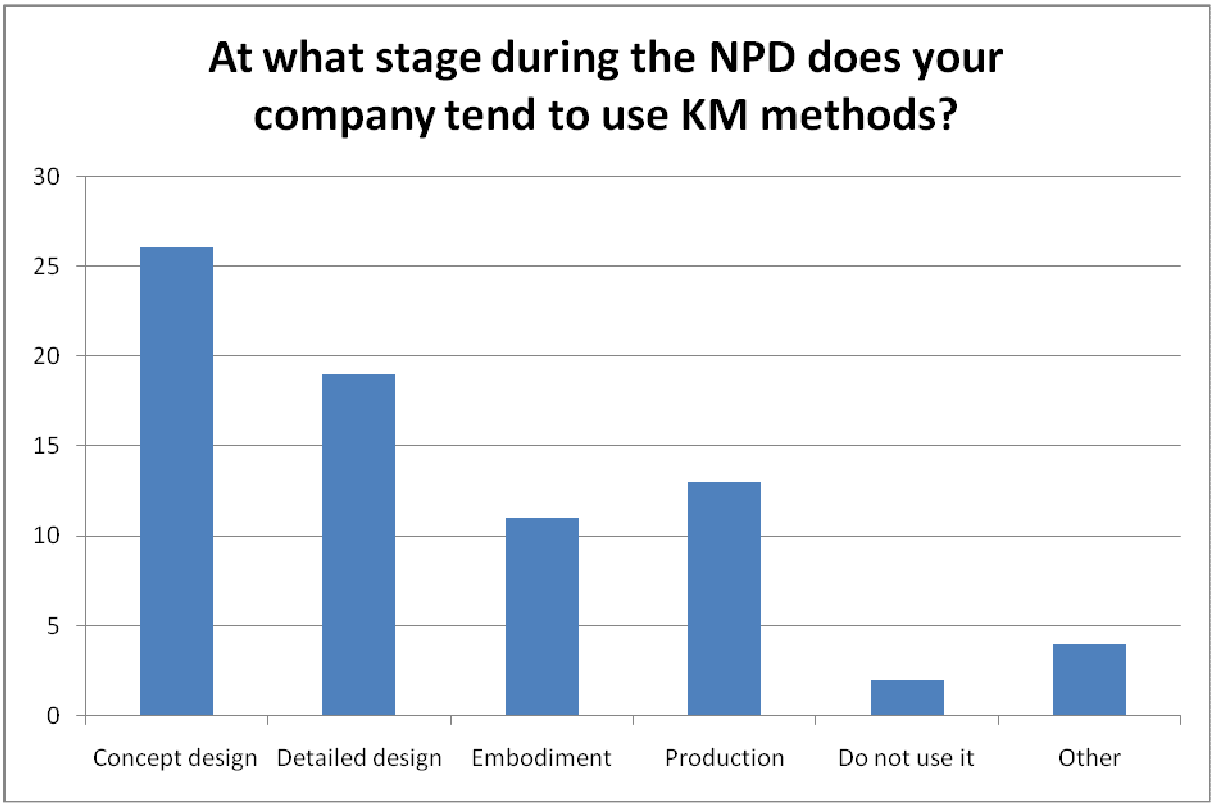


Figure 149

6.1.1 Comparison between New Zealand and Germany

In order to figure out if companies in New Zealand and Germany use knowledge management during different stages of the new product development process, both countries have been compared. The only more apparent difference could be found regarding KM processes during the production in NPD projects. This result is very close to being statistically sigificant (ANOVA p=0.07), see *Figure 154*. With a higher number of respondents this result might be more sigificant.

Concept Design

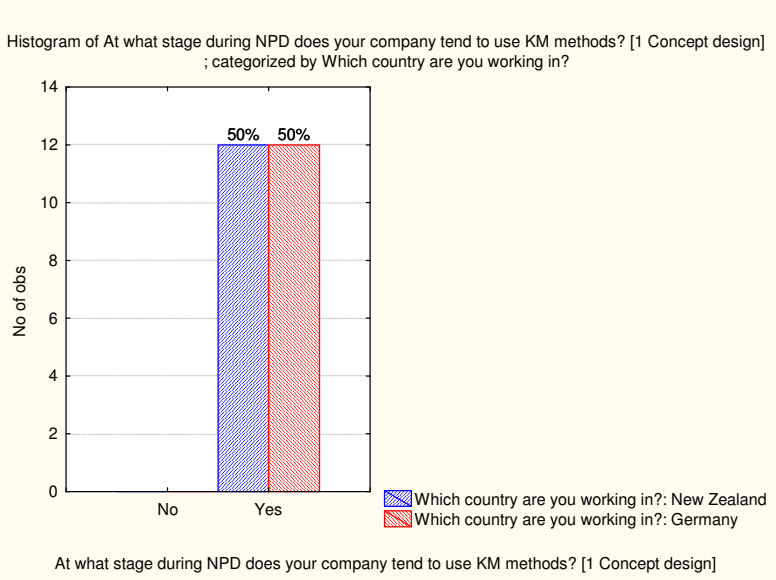


Figure 150

Detailed Design

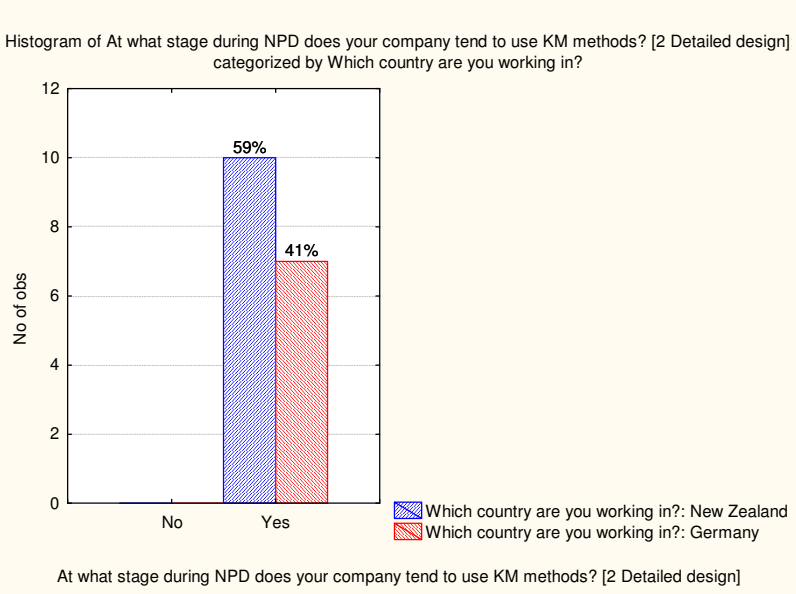


Figure 151

Embodiment

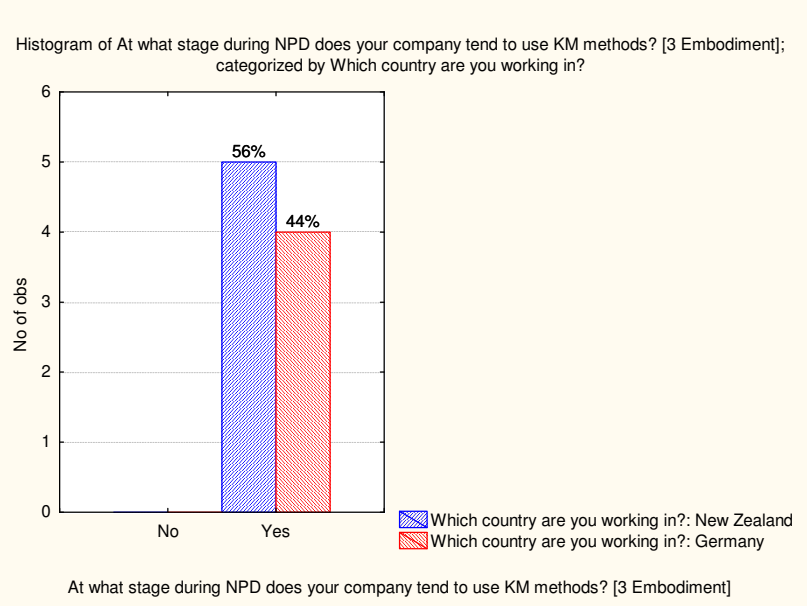


Figure 152

Production

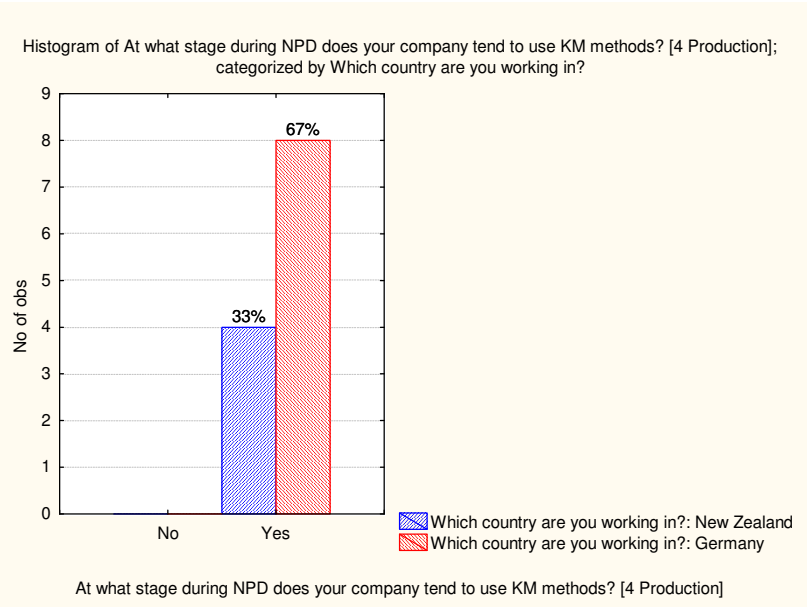


Figure 153

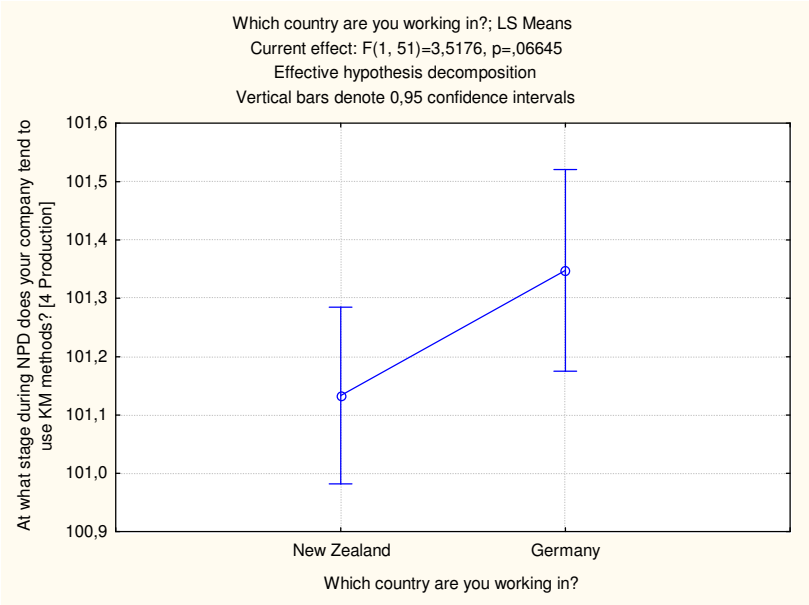


Figure 154

6.2 To what extent are you personally involved with NPD?

Figure 155 shows that 40% of the survey participants were highly involved in NPD (great or very great extent). 27% were involved to a moderate extent, and 24% were only involved to a small extent. Only 10% found they were not involved at all.

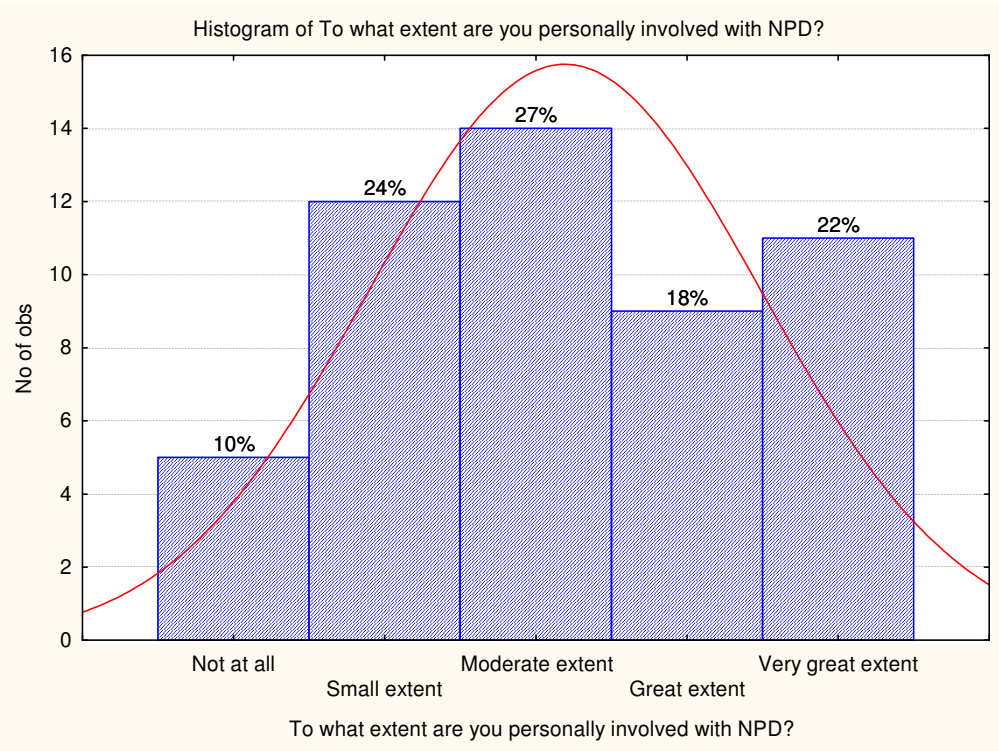


Figure 155

6.3 To what extent is your company involved with new product development (NPD)?

More than half of the surveyed companies (54%) were highly involved in NPD, see *Figure 156*. 19% were involved to a moderate extent.

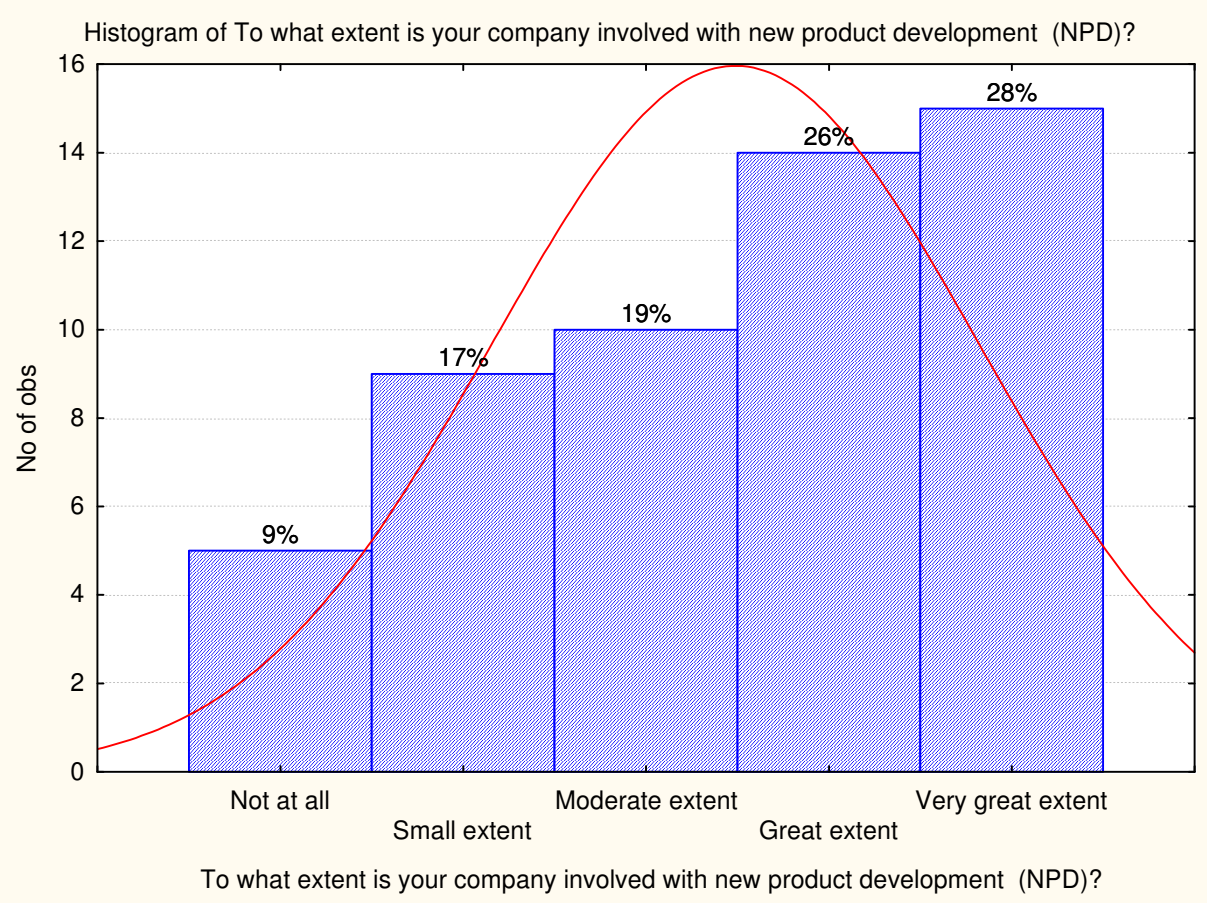


Figure 156

6.4 What are the problems as you see them regarding NPD projects?

Survey respondents thought that the most significant problems regarding NPD projects were a lack of time and inadequate communication within the organization.

6.5 Do you have any suggestions on how these problems might be solved? (Either in general or your organisational specifically).

Some suggestions were given, however, no tendency was found. A reason for that could be that the question addressed a quite general topic and was not very specific. Suggestions were, for example, better use of project teams or a change of the overall culture of the organization.

6.6 In your experience, is knowledge really important for innovation?

The results show that knowledge was considered important for innovation, see *Figure 157*. 72% of the respondents found knowledge was definitely important for innovation. 20% replied 'cautiously yes'.

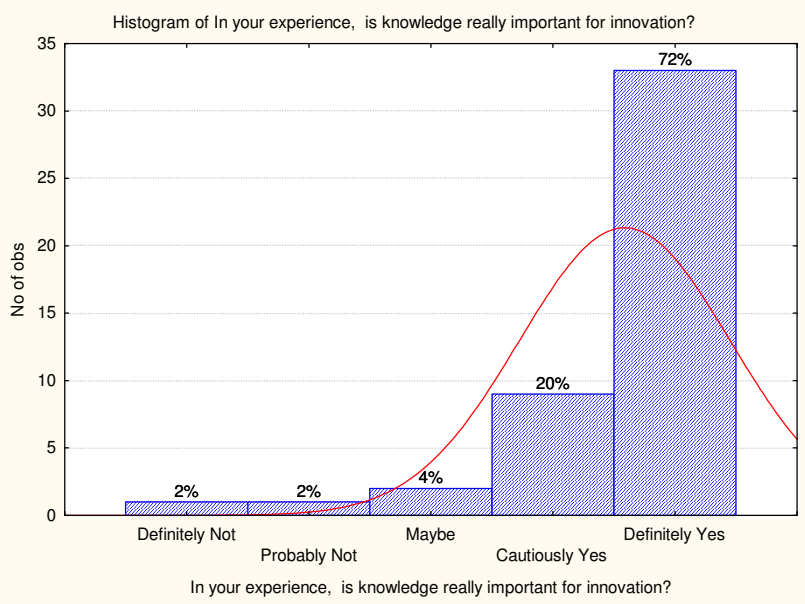


Figure 157

6.6.1 Comparison between New Zealand and Germany

No significant difference can be found. Respondents from both countries think that knowledge is important for innovation.

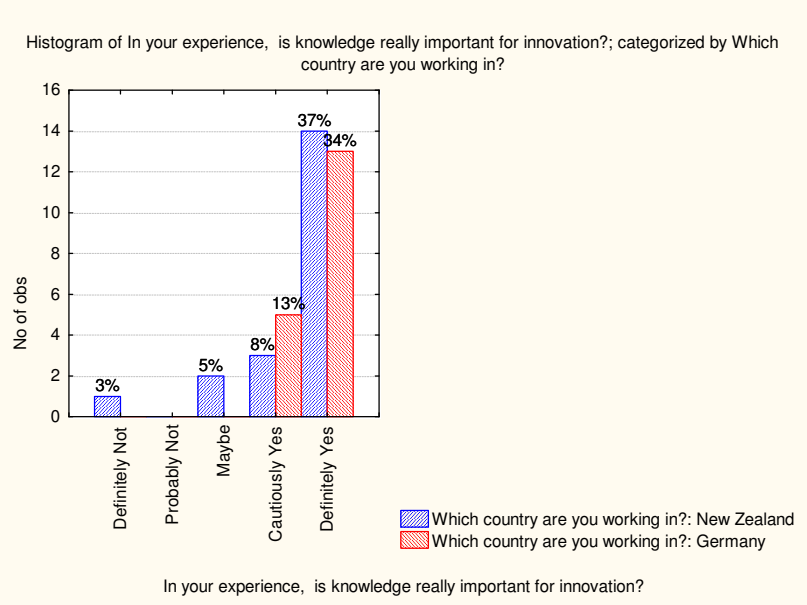


Figure 158

6.6.2 Association with KM success

Survey participants who found that knowledge was important for innovation ('definitely yes') could be associated with moderate and great success of knowledge management, see *Figure 159*.

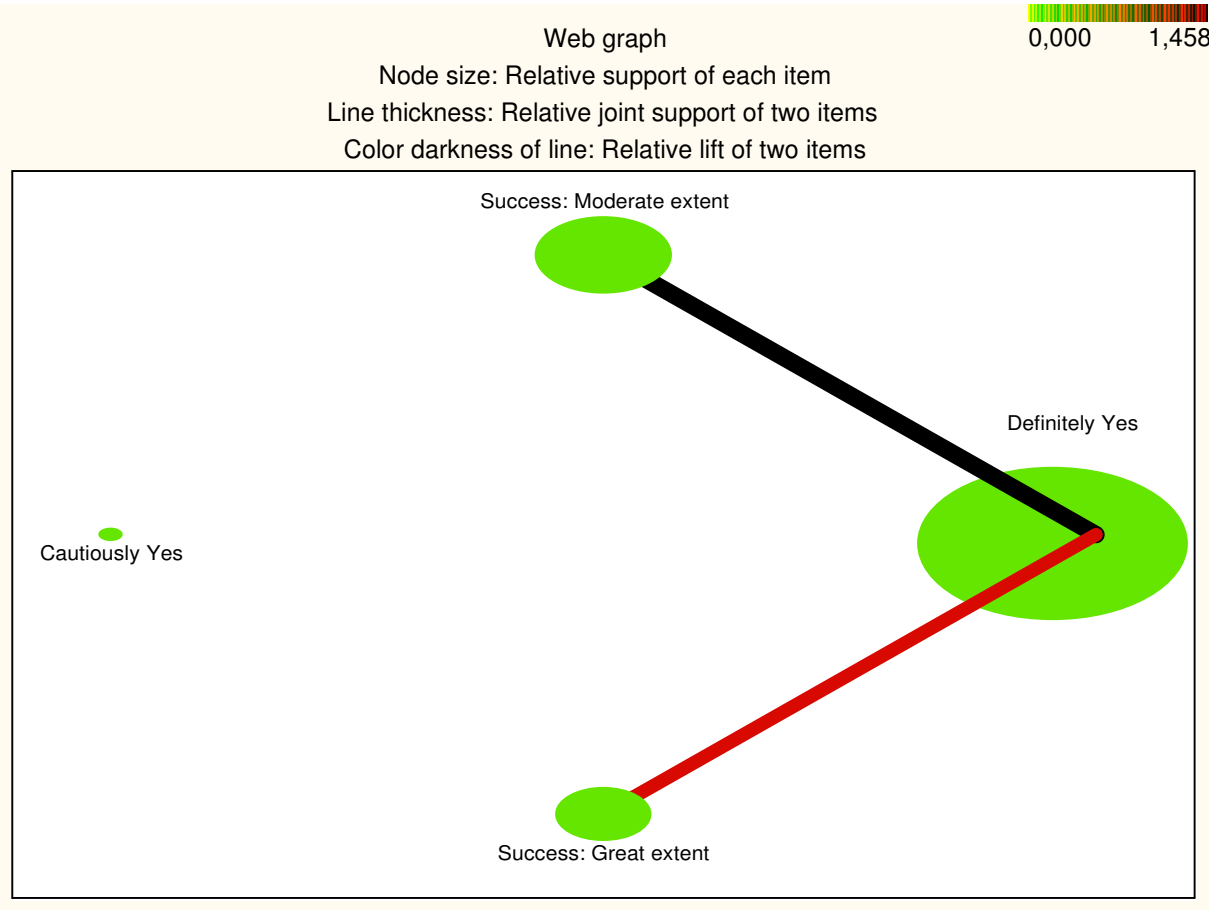


Figure 159: SAL for importance of knowledge for innovation and KM success. Min. support 0.1, confidence 0.1

Summary of association rules (University of Canterbury Resear in Workbook_1.16.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Success: Great extent	==>	Definitely Yes	13,51351	62,50000	1,401515
2	Definitely Yes	==>	Success: Great extent	13,51351	30,30303	1,401515
3	Success: Moderate extent	==>	Definitely Yes	17,56757	65,00000	1,457576
4	Definitely Yes	==>	Success: Moderate extent	17,56757	39,39394	1,457576

Figure 160

6.7 To what extent is knowledge in your opinion a competitive advantage over other companies?

On the whole the respondents found that knowledge is a competitive advantage over other companies (64% very great extent, 33% great extent), see *Figure 161*.

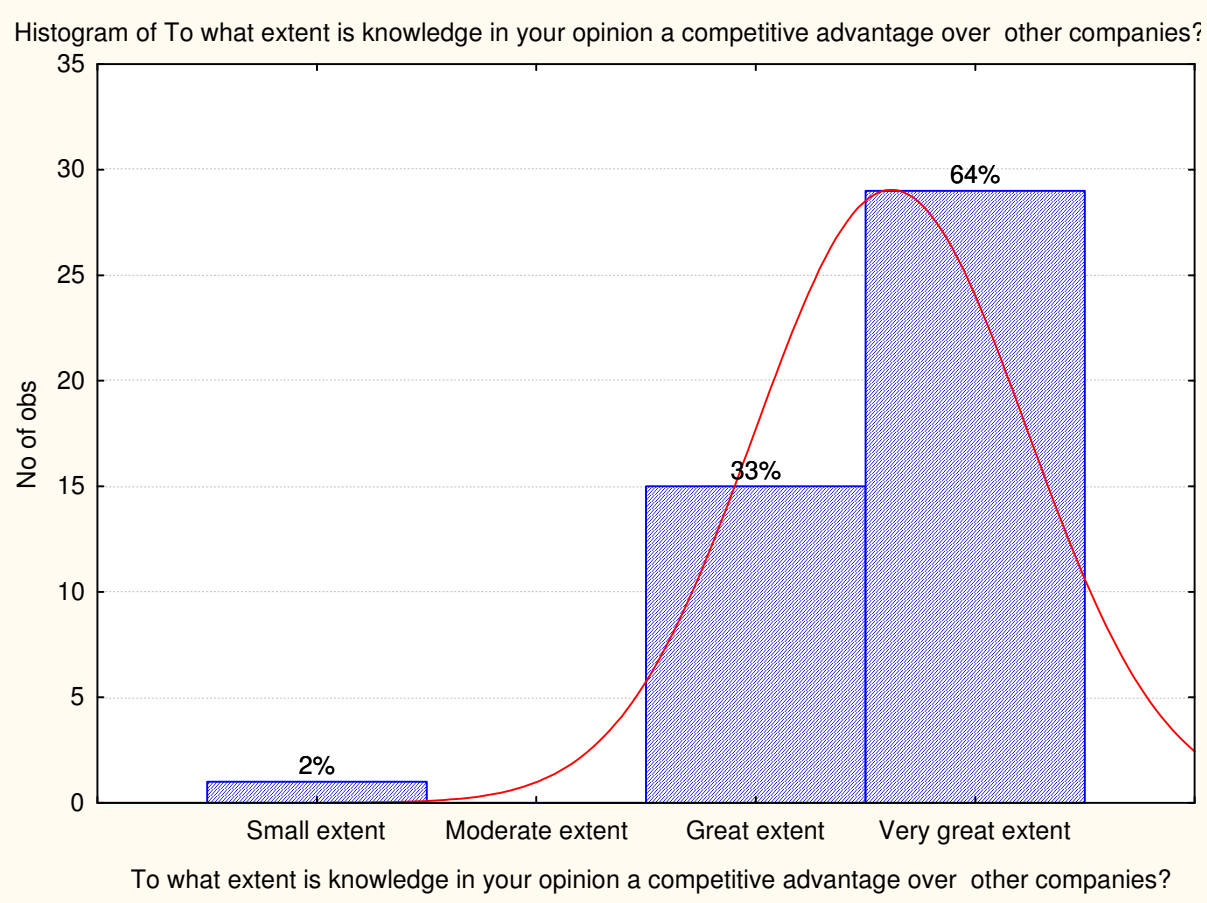


Figure 161

6.7.1 Comparison between New Zealand and Germany

Figure 161 shows that Germans tended to consider the importance of knowledge as a competitive advantage over other firms higher than New Zealanders. ANOVA showed that the difference is statistically significant (p=0,024), see *Figure 162*.

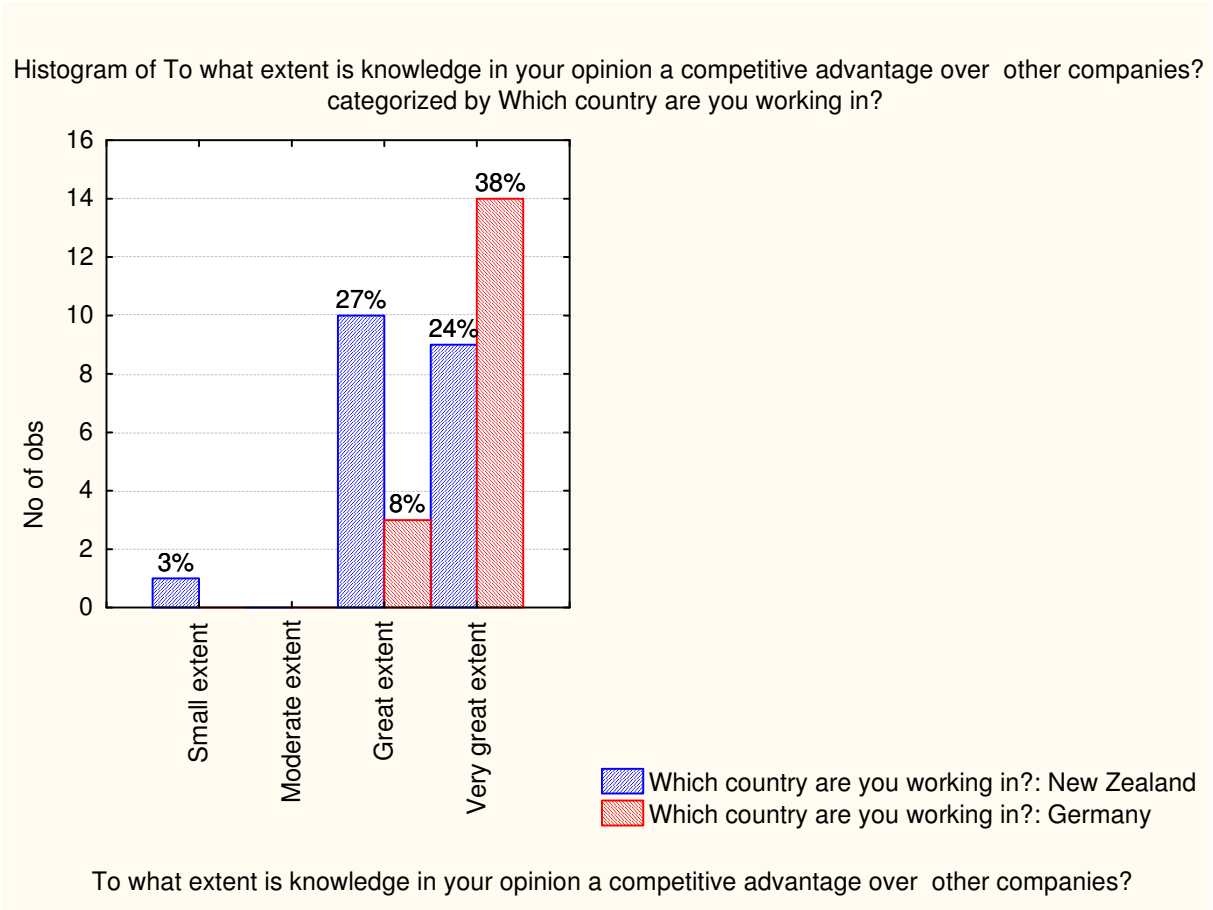


Figure 162

Figure 163

6.7.2 Association with KM success

An association between a high importance of knowledge as a competitive advantage ('very great extent') and great and moderate KM success can be seen, see *Figure 164.* Also there is an association between high importance of knowledge ('great extent') and moderate success. It is interesting to see that there only is an association between very high importance of knowledge ('very great extent') and great knowledge management success, while high importance ('great extent') could only be associated with moderate knowledge management success. Maybe this is an indication that only where there is very high awareness of the importance of knowledge successful knowledge management can be practiced.

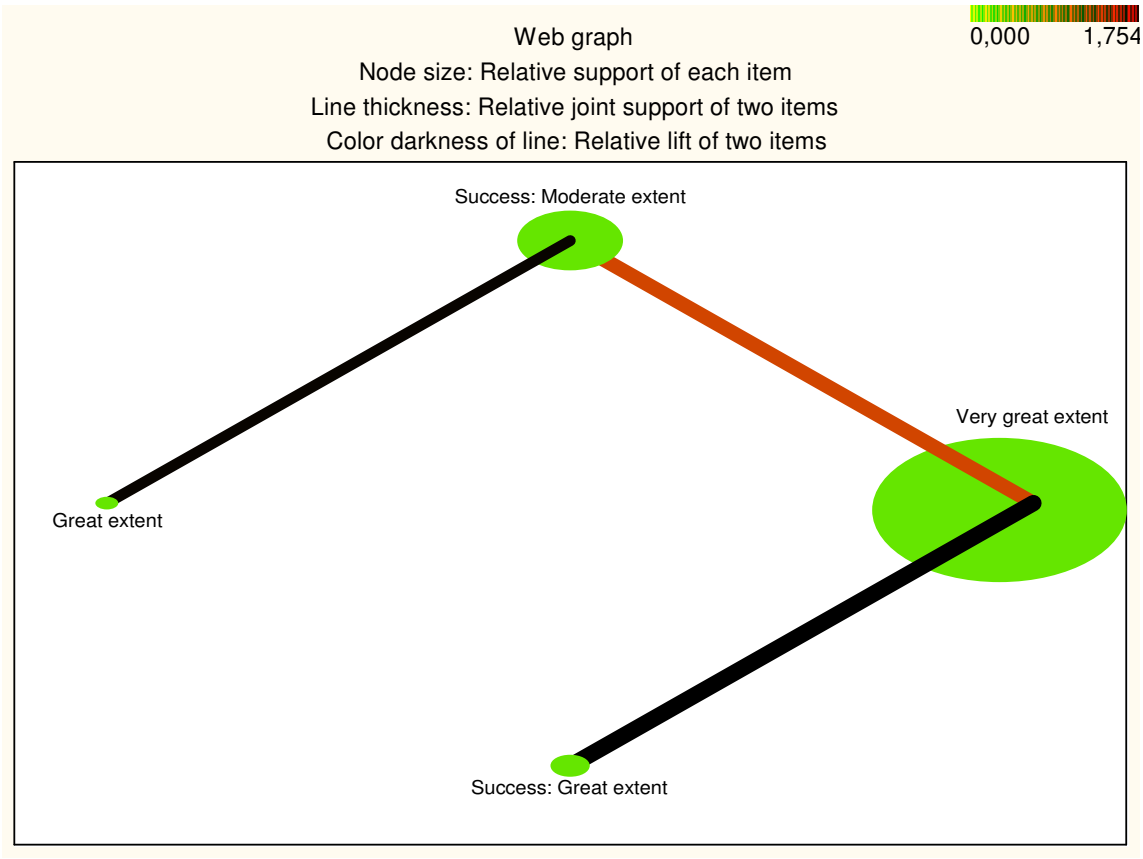


Figure 164: SAL for knowledge as a competitive advantage and KM success

Summary of association rules (University of Canterbury Resear in Workbook_1.16.stw) Min: support = 10,0%, confidence = 10,0% Max. size of an itemset = 10

	Body	==>	Head	Support(%)	Confidence(%)	Lift
1	Success: Great extent	==>	Very great extent	14,86486	68,75000	1,754310
2	Very great extent	==>	Success: Great extent	14,86486	37,93103	1,754310
3	Success: Moderate extent	==>	Very great extent	13,51351	50,00000	1,275862
4	Very great extent	==>	Success: Moderate extent	13,51351	34,48276	1,275862
5	Great extent	==>	Success: Moderate extent	9,45946	46,66667	1,726667
6	Success: Moderate extent	==>	Great extent	9,45946	35,00000	1,726667

Figure 165

6.8 To what extent does increased knowledge automatically result in innovation?

On the whole people tended to think that increased knowledge leads to innovation, however the responses are not entirely positive, see *Figure 166*.

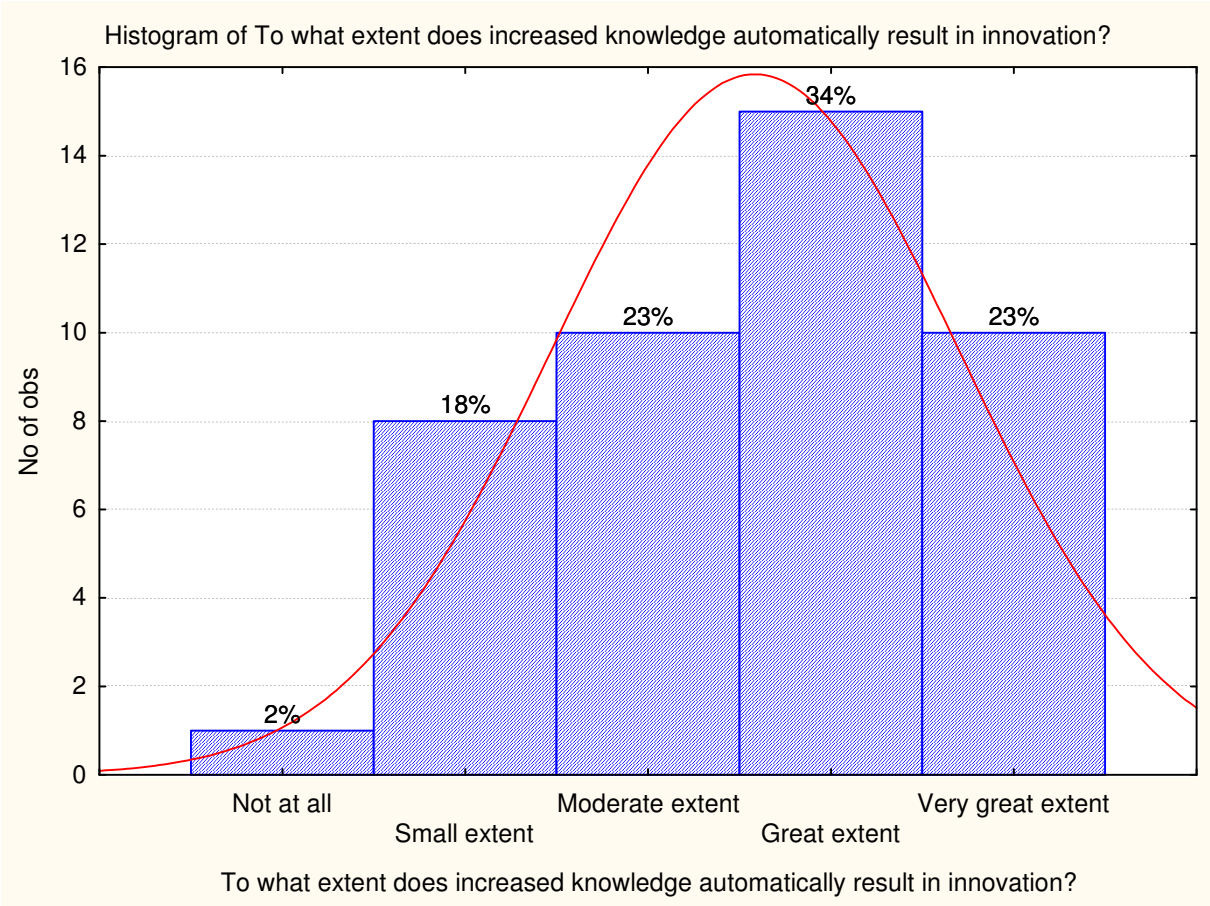


Figure 166

6.8.1 Comparison between New Zealand and Germany

A significant difference between New Zealand and Germany could be found, see *Figure 167.* Germans tended to think that increased knowledge results automatically in innovation, while New Zealanders responded more negative. This shows that the importance of knowledge for innovation might be perceived higher in German companies. ANOVA proves that the difference is statistically valid (p=0.00), see *Figure 168*.

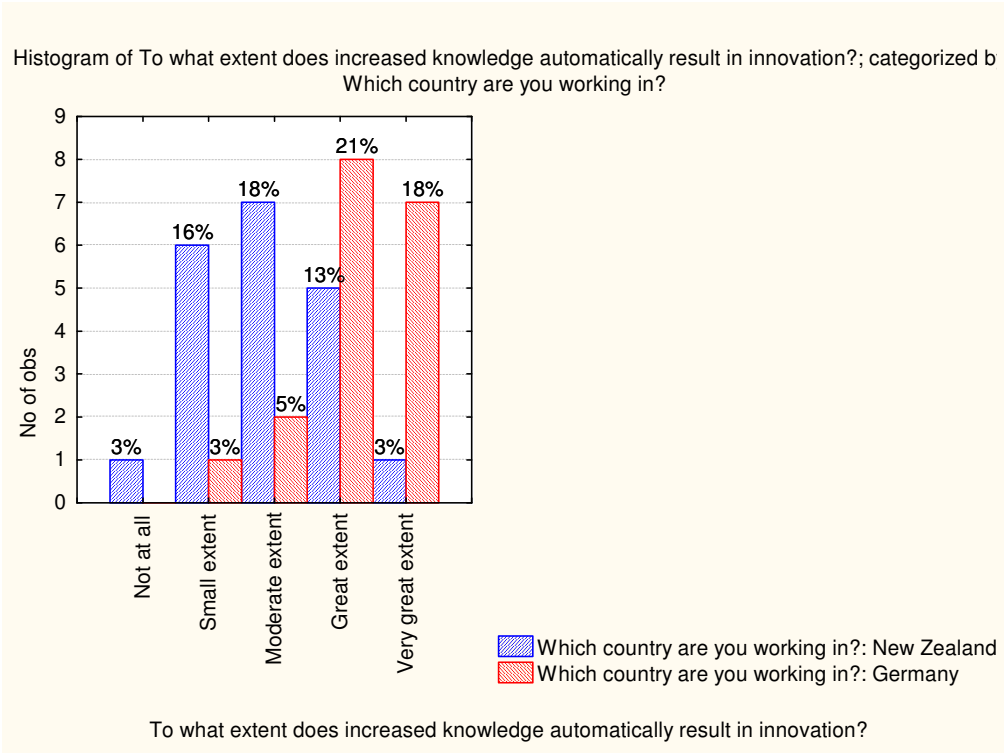


Figure 167

Figure 168

6.9 What would improve the sharing of knowledge in your organization?

Most survey respondents found that a better overall communication within their company would improve the sharing of knowledge. Also they stated that more time to share knowledge would be helpful.

7 Demographics

7.1 What type of organizational structure do you work in?

Most survey participants worked in departments. The second most common organizational structure were project teams, see *Figure 168*.

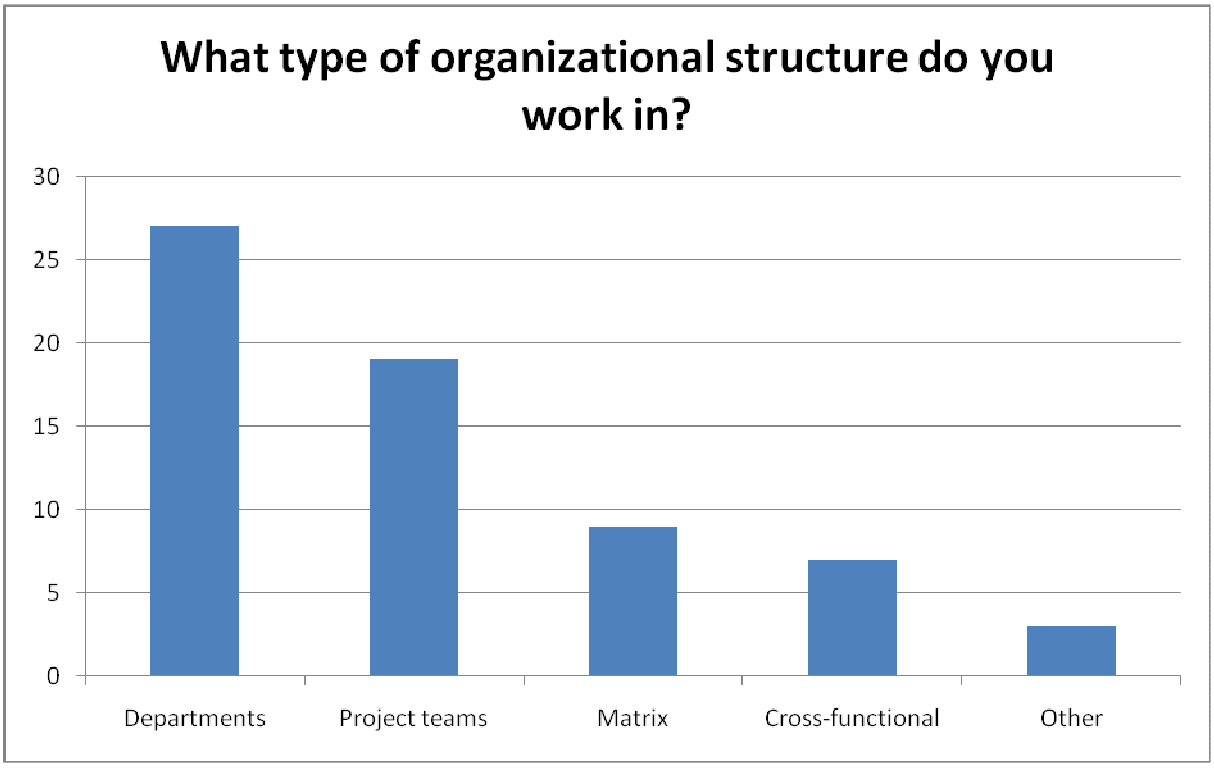


Figure 169

7.2 How many people work for your organization (approximately)?

The companies were broadly categorized into small (1-20 employees), medium (21-200 employees) and large company sizes. 13 of the surveyed companies were small, 8 were medium sized and 28 were large. The biggest company had 140,000 employees, the smallest had one. (Not every survey respondent answered this question.)

7.3 What is your gender?

Most survey participants were male (57%), while only 4% were female. 39 % decided to not answer the question.

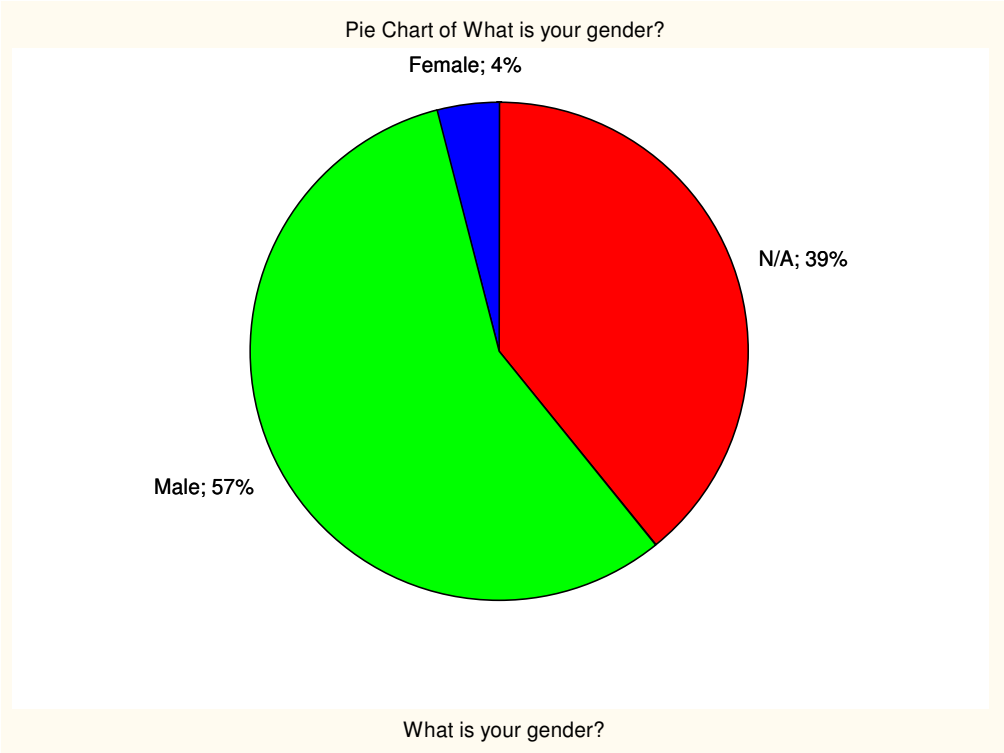


Figure 170

7.4 What is your age?

The average age of the survey respondents was about 42 years. The youngest respondent was 23, the oldest 65 years old.

7.5 What is your role?

As shown in *Figure 171*, most survey respondents worked in other roles than manager, desginer, quality engineer or team leader roles. The biggest group apart from that were the managers.

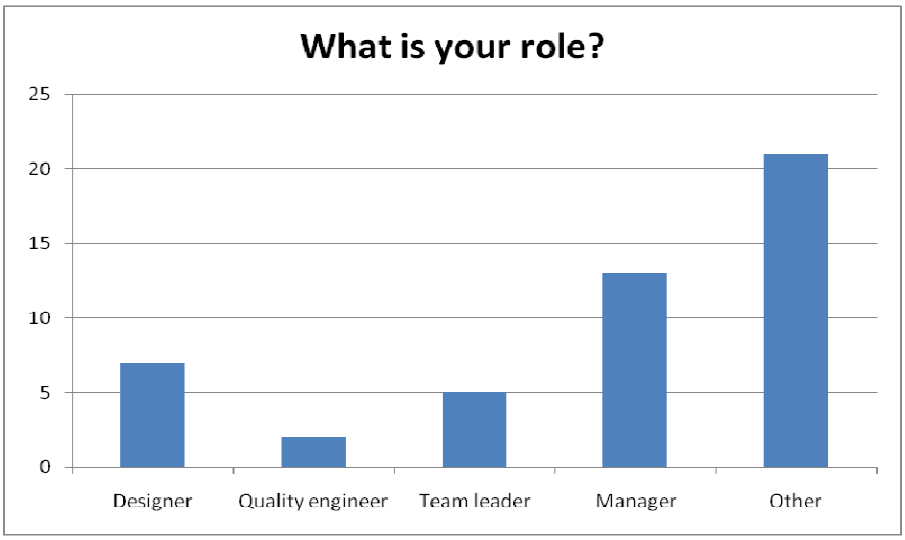


Figure 171

7.6 What is your qualification?

Most survey respondents had a Bachelor or a Masters degree, see *Figure 172*. The high number of people with other qualifications could be a result of the rather high percentage of respondents from Germany where the Bachelor and Masters system was only introduced to universities a few years ago. Before that the most common university qualification was the German diploma (Ger: Diplom).

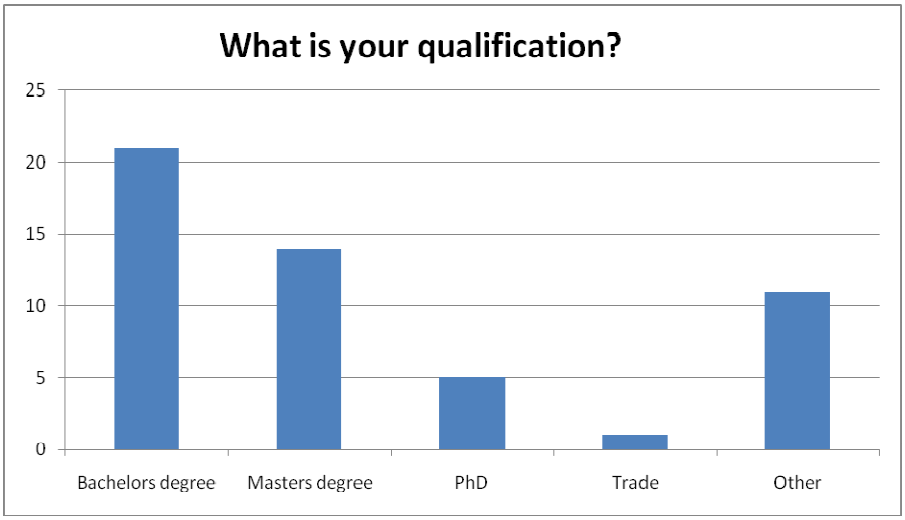


Figure 172

Appendix D:

Detailed Knowledge Management Interview Results

Question 1: Consent

People were asked to give their consent to take part in the interview after the conditions were explained.

Question 2: Do you think communication within a company (or organization) is important?

The interview results show that communication is found highly important within companies or organizations, see *Figure 1*. All participants answered 'definitely yes'. This result supports the result of a previously conducted survey by Pons ('Project management for professional engineers', Pons 2010, research poster presented at 2010 PMI conference in Wellington).

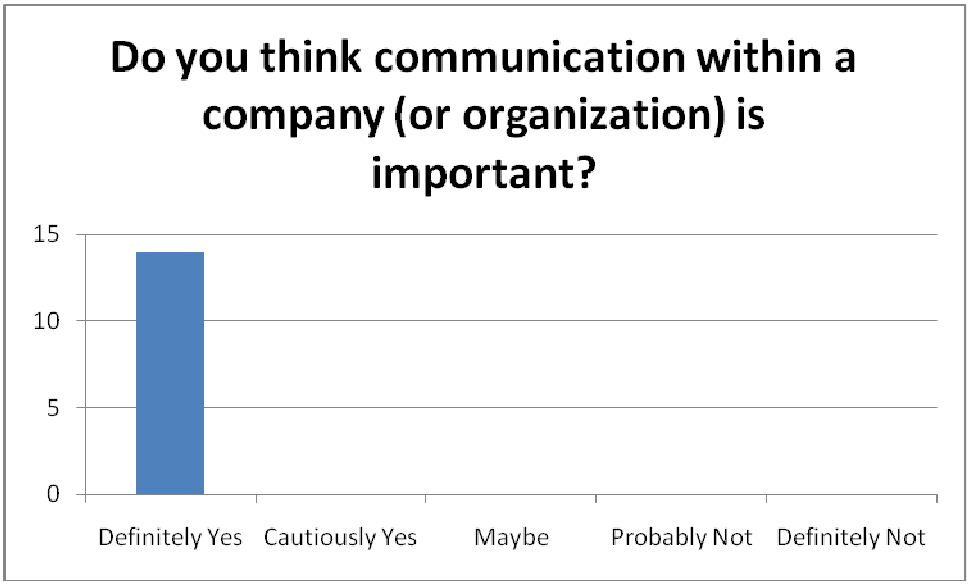


Figure 1: Importance of communication for a company or organization.

Question 3: What do you understand by the term 'communication'?

8 out of the 14 respondents (see gray answers) mentioned at least one KM process when being asked about communication. That implicates that many people might associate certain parts of KM with communication. This is interesting as previous surveys ('Project management for professional engineers', Pons 2010, research poster presented at 2010 PMI conference in Wellington) pointed out the importance of communication for engineering companies. While communication was ranked most important, KM was considered not very important. Maybe the term 'KM' is not very well known. The interview question 4 supports that assumption.

1. Participant
    - Transferring information and knowledge
    - Sharing opinions
    - Working on relationships to co-workers
    - It is important to have a common understanding regarding the different forms of communication
2. Participant
    - Transparency of work people are doing and have done
    - Documentation of completed work
    - Updating and social communication
3. Participant
    - People get very special information
    - Give feedback to react quickly
    - Provide and contribute ideas
    - Training and work- shops
    - Knowledge sharing
    - People should be able to get relevant training and specialize
4. Participant
    - Getting a common understanding of goals and responsibilities
    - Half of the communication would be direct, like personal conversations. While the other half would be indirect through means of technology, e.g. e-mails.
5. Participant
    - Getting common understanding and adjusting responsibilities
    - Acquiring specifications
6. Participant
    - Common understanding regarding problems and tasks
    - Talking to co-workers
    - Informal and formal parts of communication (e.g. personal conversations versus presentations)
7. Participant
    - Technical communication
    - Sharing knowledge between co-workers and specialists
    - Communicate in multi-disciplinary environments

8. Participant
    - Communicating customer requirements
    - Documenting designs, standards, specifications, design intend and meetings
    - Formal processes
9. Participant
    - Writing communication (e.g. e-mails)
    - Meetings, also between different departments
    - Clear definition of goals and requirements
    - Defining methods
10. Participant
    - Young engineers and people who are new in the company need to be taught (knowledge transfer)
    - Mentor programs
11. Participant
    - Transferring knowledge
    - Creating better relationships with colleagues
    - Better communication leads to better results
12. Participant
    - Setting direction
    - Defining specifications
    - Avoiding redundant work
    - Knowing what co-workers work on and clarifying the responsibilities
13. Participant
    - Everything from verbal to written conversation
    - Essential for definition of objectives and task distribution
    - Alignment of purpose and strategy
14. Participant
    - Talking
    - E-mails
    - Alignment of purpose and strategy
    - Incentives

Question 4: Have you heard of the term 'knowledge management' before?

As shown in *Figure 2,* most people do not seem to be familiar with the term 'knowledge management'. Only four interviewed people were sure that they had heard of the term before. It is likely that the term is not well known among practitioners.

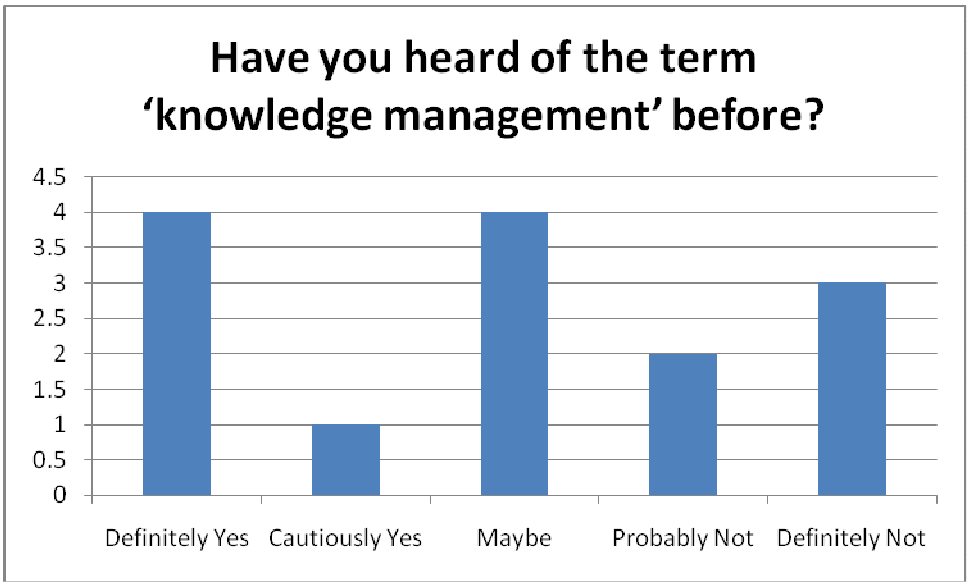


Figure 2: Familiarity with the term 'knowledge management'.

Question 5: How important do you think knowledge management is for your business (organization)?

All interviewed people, apart from one, found that knowledge management was important for their business to a great or very great extent, see *Figure 3*. This points out the importance of KM especially for NPD companies and engineers involved in the process, thus it is critical to optimize KM practices for the highest possible success.

Figure 3: Importance of knowledge management for own business or organization.

Question 6: Which knowledge management strategy do you prefer, codification or personalization? Please explain.

On the whole there was a tendency towards the personalization strategy, as people felt that the depth of knowledge which can be transferred was higher. The main advantage of codification according to the interview participants was that knowledge was accessible all the time and that personal relationships were irrelevant for the sharing process. Also people found that codifying knowledge made the company less vulnerable to staff leaving. However, it was interesting to see that most people pointed out the importance of both strategies supporting each other. No company seemed to put all their emphasis only on one of the two approaches. Either a database was used to find relevant information to acquire common knowledge about a particular topic for discussions or meetings, or databases were used to find experts within the organization. In companies where the emphasis was put on the codification strategy, meetings were still important. Also employees would approach co-workers to find relevant knowledge in databases. In general both strategies seemed to support each other.

1. Participant
    - Main way to share is through codification
    - A lot of people can be involved and the NPD process can take rather long
    - Direction is set through management
2. Participant
    - Both need to be handled well
    - Codification is important to find out what was done and by who, especially when staff is leaving the company
    - Personalization is very important too
3. Participant
    - Prefers personalization
    - Problems with codification: hard to codify knowledge through language, some knowledge cannot be codified
    - More detailed knowledge transfer
    - More creativity
4. Participant
    - Prefers personalization
    - Deeper knowledge transfer, more details
    - Questions and discussions can evolve during conversations
    - Codification needs to be used as well to find relevant experts, hence, training and good search tools are important
5. Participant
    - Prefers codification
    - Access to knowledge all the time, no dependency on the availability of others
    - Training for efficient use of databases
    - Uses personalization to find relevant documents
6. Participant
    - Prefers personalization, but thinks that both are important
    - No discussions possible with codification, no feedbacks
    - Personalization is more powerful during more static times, while many standards and guidelines
7. Participant
    - Codification often times limited due to poorly formalization
    - It is hard to find data, but once found it can be helpful
    - Problem seen with personalization is that you need to have the relevant contact and they could have left the company
8. Participant
    - Prefers personalization
    - Codification allows people to find many regulations and requirements standardized by the company
    - Experience and expertise are hard to codify
    - Discussions are still most valuable
9. Participant

- Prefers personalization
- Deeper and clearer knowledge can be transferred
- Databases tend to be less accurate
- Personalization allows combination and optimization of knowledge
- High customization is possible
- Knowledge transfer needs to be ensured
- Specialists have to be known / a way to find them must be provided

10. Participant
    - Prefers personalization
    - Customer contact can be learned best through mentoring
    - Not all the relevant knowledge can be codified
11. Participant
    - Both are equally important
    - Databases have to be used properly (work-shops)
    - Quality of documents needs to be high ensuring high efficiency of database
    - Discussions are still important
12. Participant
    - Prefers codification
    - Main advantage is the accessibility and the fact that there is no dependency of other people once the document has been stored
    - Personal relationships can disturb the personal knowledge sharing process
13. Participant
    - Prefers codification
    - Knowledge can be conserved better through codification
    - Found that personalization is imprecise and that content easily got lost
    - Some personalization processes are essential
    - Both strategies should support each other
14. Participant
    - Prefers personalization
    - Face-to-face time is most important (most value, not necessarily the most information)
    - Codification is still essential
    - Database to store knowledge is important

Question 7: In your opinion, which of these strategies is used in your company? How is it applied?

The interview results show that management awareness of KM is essential for its success. Every participant who found that their company used a successful or very successful approach said that management set direction and that there were standards for knowledge sharing. Databases need to be kept tidy, and in most cases there were people responsible for this particular task. Moreover training or assistance as to using the databases efficiently was found important, as well as sophisticated tools to search for knowledge. Formal meetings seem to be important to enforce knowledge exchange between employees of one department or project team and also between different departments. Overall a culture that encourages knowledge sharing and a clear strategy on how this is to be done seem critical.

1. Participant
    - Direction is set through management
    - Encouragement to use codification
    - Data stored at a central place by people responsible to keep database tidy
    - Meetings and discussions are still an important part of the NPD process
    - Management provides guidelines as to how codification should be used
    - Employees can contact co-workers in the library to help them find data
    - Data is used to get basic knowledge and common understanding of a topic before meetings and discussions
    - 60% codification / 40% personalization
    - Successful approach
2. Participant
    - Codification is mainly used
    - Not a strong emphasis on personalization, but there are meetings
    - Engineering team started codification approach which has been embraced by management (still ignorant)
    - No formal training to use database
    - Team leaders are responsible for the database
3. Participant
    - Emphasis on personalization
    - Common knowledge is supposed to be codified and stored in database
    - Formal meetings
    - Areas for informal meetings
    - Employees of different departments meet for brain storming and exchange of ideas
    - Although the perceived emphasis is put on personalization, personalization 50% / codification 50%
4. Participant
    - Frequent formal meetings
    - Management awareness
    - Direction set through management
    - Circle of experts for knowledge transfer and discussions
    - Training for database

- Clear tools to find experts
- 70% personalization / 30% codification
- Very successful approach

5. Participant
    - Emphasis on codification
    - People assigned to keep it tidy
    - Formal meetings
    - Meeting points to encourage communication
    - Common understanding through database
    - Great depth of knowledge through experts

6. Participant
    - Databases are used so people can get information on standards
    - Formal monthly meetings of specialists for knowledge exchange
    - Personalization 80% / codification 20%
7. Participant
    - Emphasis on personalization
    - Knowledge is in databases, but is then discussed
    - Personalization (asking colleagues) is used to find the right document first
    - Both strategies support each other
    - Personalization 50% / codification 50%
8. Participant
    - Databases are mainly used
    - There are formal meetings too
    - Codification 60% / personalization 40%
9. Participant
    - Emphasis on personalization
    - Management awareness
    - Directions set through management
    - Meetings regular and random, formal and informal
    - Clear protocols of meetings
    - First personalization, then documentation of findings (codification)
    - Through databases experts can be found
    - Personalization 70% / codification 30%
    - Very successful approach
10. Participant
    - Both applied, but too little
    - Low priority
    - Databases are used
    - Mentor programs
    - Personalization 50% / codification 50%
11. Participant
    - Frequent use of database

- Both are applied, but codification is used more often
- KM strategy also depends on the set-up of the office (communicative work-climate?)
- Codification 70% / personalization 30%

12. Participant
    - Both are used equally and support each other
    - Knowledge can be found in databases
    - Informal discussions with co-workers to seek knowledge from them
13. Participant
    - People write down knowledge at different stages of the NPD process
    - Formal meetings across the business
    - Company uses a network drive
    - No dedicated search tool to find knowledge
    - Redundant documents
    - Find the person, find the document
    - Ad hoc
14. Participant
    - Folders for projects on network drive
    - Throughout the process of NPD knowledge transfer through informal meetings
    - Company uses a network drive
    - No dedicated search tool to find knowledge
    - Redundant documents
    - Find the person, find the document
    - Ad hoc

Question 8: What could be done to improve the current knowledge management process?

The suggestions to improve knowledge management processes varied between participants. One of the most significant issues seems to be a low awareness of KM, its importance and benefits not only among management, but also among staff. While time and a low priority were mentioned a few times, some people also found that co-workers had a low motivation or willingness to share their knowledge. A possible reason for that could be personality factors (e.g. maintaining a certain position as an expert within the organization) or simply a low awareness of the benefits of sharing knowledge.

1. Participant
    - Reports are only created at the end of the project, knowledge transfer during the project could be improved
    - Management of the logbook of engineers could be improved
2. Participant
    - New modern internet tools could be used more (social networking, wikis and blogs), hard with older employees though
3. Participant

- Personalities make knowledge sharing hard
- Cultural problems can be seen
- People's mentalities as a problem

4. Participant
    - Store (codification) older projects better, as experts are not available anymore
    - Time is an issue
5. Participant
    - Database needs to run properly and needs to be maintained
    - Some employees do not want to share in order to maintain their position (own importance)
    - Overall flow of information should be improved
6. Participant
    - More face to face time
    - People have to develop a feeling for their co-workers and get to know them fast
    - New personal needs to be integrated faster (faces have to be known)
    - Low awareness of KM
7. Participant
    - Decent document control system to ensure quality data
    - Cataloging info
    - Easier access
8. Participant
    - Experienced staff needs to share knowledge better
    - Better oversight on other projects should be ensured
    - More reviews during projects would help
9. Participant
    - Process to find the solution to a previous problem should be documented more, not only the outcome
10. Participant
    - KM is no priority
    - Lack of time to share
    - Direction through management needs to be given
    - Awareness of older, more experienced staff needs to be stimulated. They need to pass their knowledge more
11. Participant
    - Meetings where experienced staff can pass knowledge on to new staff
    - Different company branches need to be linked better to avoid redundant work
12. Participant
    - Time to create documents
    - Direction needs to be set through management
13. Participant
    - KM awareness is too low
    - Low perceived value of KM
    - Search tools

- Tidier network drive (database)
- Sophisticated KM software
- More formal presentations and meetings of experts

14. Participant
    - KM awareness is too low
    - Low perceived value of KM
    - Search tools
    - Tidier network drive (database)
    - Sophisticated KM software
    - More formal presentations and meetings of experts

Question 9: To what extent are you personally involved in new product development? Can you give some examples?

Based on the answers given and the position the survey participants had in their companies, the involvement in NPD processes was rated, see *Figure 4*. It can be seen that most participants were involved to a great or very great extent in NPD; hence their opinions are valuable for this research.

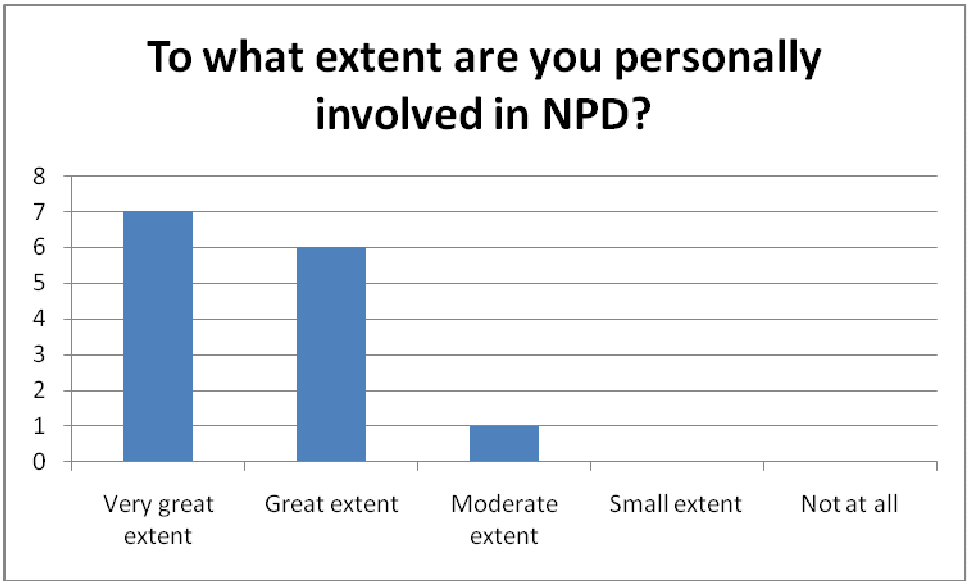


Figure 4: NPD involvement of interview participants.

APPENDIX E: HEC ETHICS APPROVAL FOR SURVEY

Ref: HEC 2010/27/LR

24 May 2010

Volker Wochele
Department of Mechanical Engineering
UNIVERSITY OF CANTERBURY

Dear Volker

Thank you for forwarding to the Human Ethics Committee a copy of the low risk application you have recently made for your research proposal "Actual practices of New Zealand industry regarding use of knowledge management in engineering new product development".

I am pleased to advise that this application has been reviewed and I confirm support of the Department's approval for this project.

This approval is subject to the following:

- Please move the researcher and supervisor contact details to the front of the survey.
- It is noted in the information sheet that a suggested 15 minutes for answering 50 questions may be somewhat underestimating the time involved.
- The HEC will need to see any attachment for interview questions. It is suggested that the applicant file an amendment letter to the HEC when the time comes to conduct interviews as things may change from the survey.

With best wishes for your project.

Yours sincerely

Dr Michael Grimshaw
Chair, Human Ethics Committee

APPENDIX F: HEC ETHICS APPROVAL FOR INTERVIEWS

Human Ethics Committee

Tel: +64 3 364 2241, Fax: +64 3 364 2856, Email: human-ethics@canterbury.ac.nz

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Ref: HEC 2010/55/LR

9 August 2010

Volker Wochele
Department of Mechanical Engineering
UNIVERSITY OF CANTERBURY

Dear Volker

Thank you for forwarding to the Human Ethics Committee a copy of the low risk application you have recently made for your research proposal "Actual practices of New Zealand industry regarding use of knowledge management in engineering new product development".

I am pleased to advise that this application has been reviewed and I confirm support of the Department's approval for this project.

However, this approval is subject to the inclusion of the following statements in the introduction to participants:

- A Masters of Engineering is a public document via the UC library database.
- The project has been reviewed and approved by the UC Human Ethics Committee low risk process.

With best wishes for your project.

Yours sincerely

PP JCGrimshaw

Dr Michael Grimshaw
Chair, Human Ethics Committee

APPENDIX G:

PMI RESEARCH ACHIEVEMENT OF THE YEAR 2010 AWARD

PMI New Zealand

Project Management Institute of New Zealand
Project Management Awards

Winner

Research Achievement of the Year 2010

Dr Dirk Pons, Prof John Raine and Volker Wochele

Project Management for Professional Engineers

For research that has advanced the concepts, knowledge and practices of project management

Karen Clarke
President PMINZ

25 August 2010
Date

PMI Conference 2010 in Wellington, NZ

Shown below, the official picture of the award ceremony after winning the 'Research Achievement of the Year 2010' award.

From left to right: PMI NZ President Karen Clarke, Volker Wochele, PMI NZ Vice President Sean Whitaker.

Scaled down award winning research poster from the 2010 PMI NZ Conference in Wellington

Project Management for Professional Engineers

Dirk Pons, John Raine, Volker Wochele

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Research Question

- Which components of project management are important for professional engineers?

Purpose

- Potential to improve the process for training graduate engineers.
- More effective Professional Engineers as a long term result.

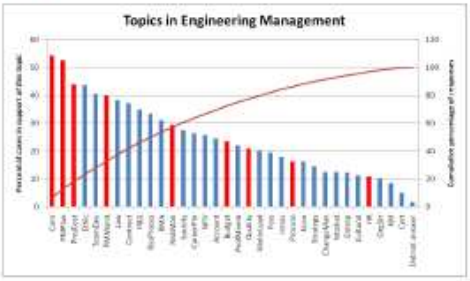
Introduction

Project management is a large body of knowledge in its own right, and it cannot practically all be taught to undergraduate Engineers. But what should be taught? What should be left out?
While the bodies of knowledge for engineering sciences, e.g. fluid mechanics, are well established and show consistency across teaching institutions, the same cannot be said of engineering management. How does an accrediting team know whether there is sufficient engineering management, professional practice, and soft skills in a particular programme? It is therefore worth having greater clarity about precisely what is meant by 'project management' in the professional engineering context. There is a lack of differentiation between the subcomponents of project management.

Survey

- New Zealand Professional Engineers who are members of the Institute of Professional Engineers NZ (IPENZ)
- Includes all practice areas
- IPENZ annual survey with the number of responses received was 2200, representing a 40% return.

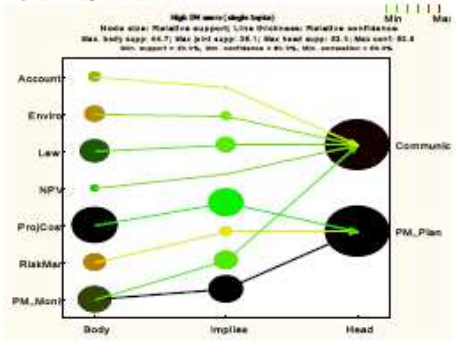
The chart shows the various project management topics that were important for Professional Engineers. Those relevant to the 'Body of Knowledge (PMBOK)' (PMI, 2008) were high-lighted:



Engineers felt that the most important topics were

- communication
- project planning

ARA for high engineering management users in the Mechanical Engineering practice areas shows **communication** and **project planning** as the most important activities, supported by a variety of knowledge areas on the left.



Outcomes:

These results show that project management has a unique and important contribution to make to the practice of other professions. Further, that of the various sub-topics within the project management body of knowledge, project planning is the most important. Also communication is considered very important.

Implications for professional engineers:

Those practising Engineers who have a mind to professional development in the project management areas would be advised to start **developing their skills in project planning**, as that is the most import of the PM topics.

Implications for teaching:

The core project management topics are (in descending order): **Communication, Project Planning; Project Costing; and Project Monitoring.**
Furthermore, the other elements of the PMBOK nine knowledge areas also featured, to various extents. While the PMBOK on its own does not cover all the topics required for the development of a Professional Engineer, it is notable just how much it *does* cover.

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Prof. John Raine
Auckland University of Technology

Volker Wochele
University of Canterbury
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PMI (2008). *A guide to the project management body of knowledge (PMBOK guide)* (4 ed.). 14 Campus Blvd, Newtown Square, Pennsylvania, USA: Project Management Institute. ISBN 978-1-933890-51-7

P

In text:

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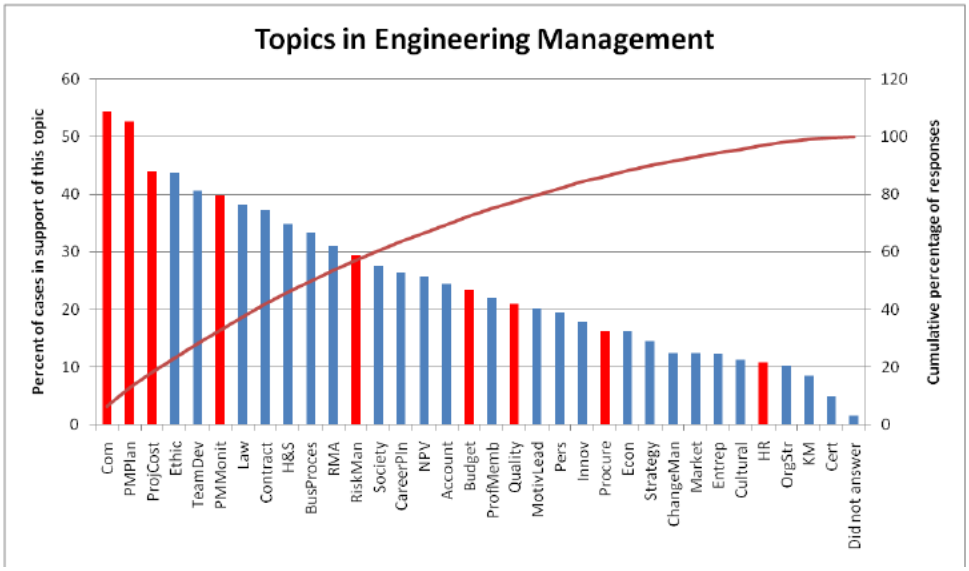

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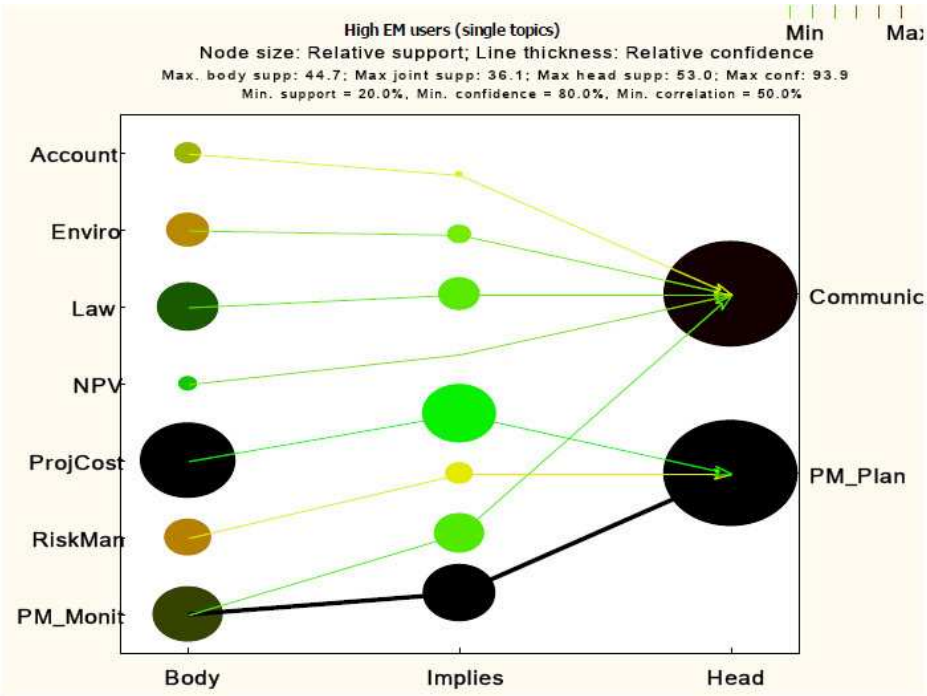

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Those practising Engineers who have a mind to professional development in the project management areas would be advised to start **developing their skills in project planning**, as that is the most import of the PM topics.

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The core project management topics are (in descending order): **Communication**, **Project Planning; Project Costing; and Project Monitoring.**

Furthermore, the other elements of the PMBOK nine knowledge areas also featured, to various extents. While the PMBOK on its own does not cover all the topics required for the development of a Professional Engineer, it is notable just how much it *does* cover.

Dr. Dirk Pons Prof.; John Raine; Volker Wochele